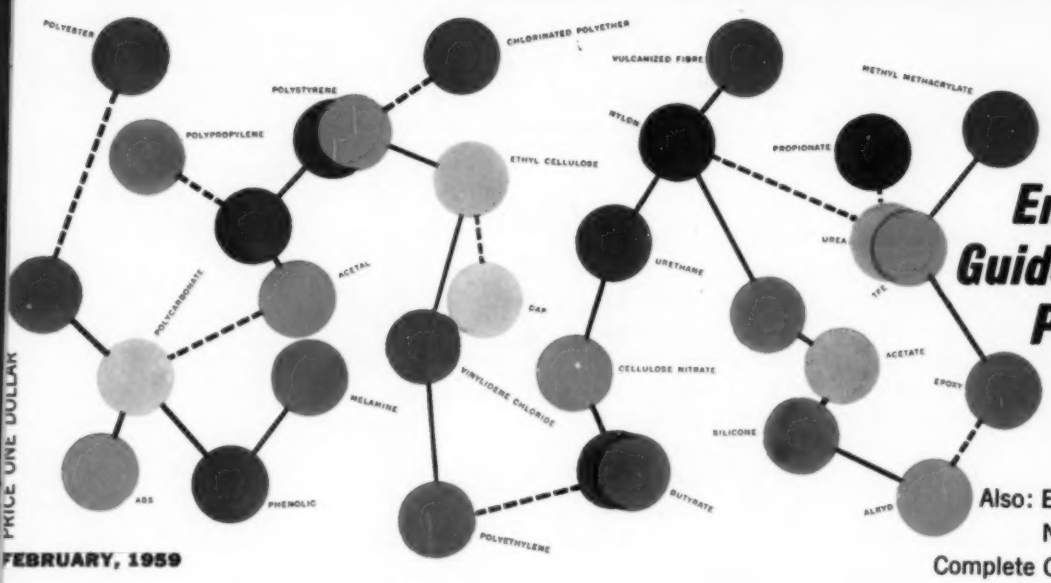
Materials in Design Engineering

FORMERLY
MATERIALS
& METHODS

SELECTION & USE OF METALS, NONMETALLICS, FORMS, FINISHES



Engineer's Guide to Plastics

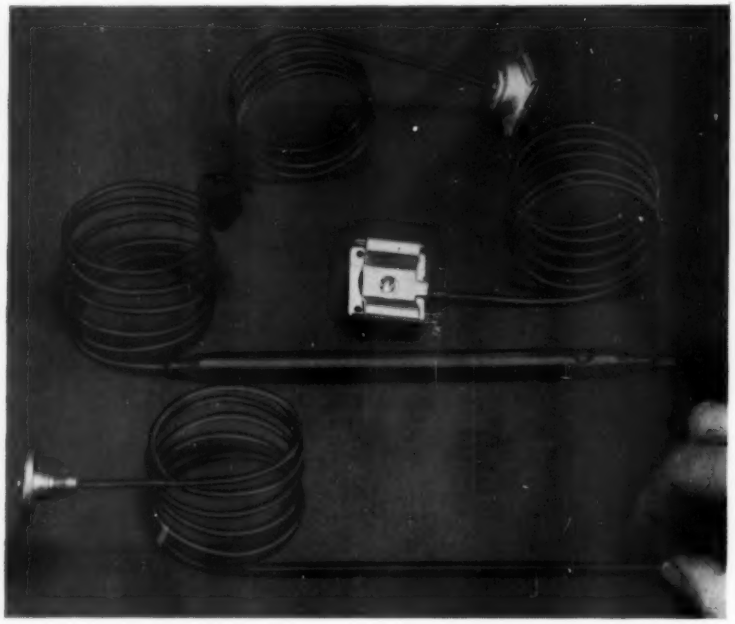
Manual No. 156

Also: Explosive Forming
New Wrought Iron
Complete Contents—page 1

PRICE ONE DOLLAR

FEBRUARY, 1959

10 TO 15 NEW JOBS a week, each a different application, require a continuous program of evaluating the properties of metals and fabricating costs at Robertshaw-Bridgeport.



In making bellows (left) and temperature sensors (above) to meet ever-changing needs of control, appliance, and industrial equipment manufacturers, Bridgeport Thermostat Div., Robertshaw-Fulton Controls Co., Milford, Conn., averages 10 to 15 new problems a week. Specifications vary widely in dimensions and physical characteristics. Dependable performance over long periods of uninterrupted service is vital—yet costs must be rigidly controlled.

So for quality with maximum economy in fabrication, materials must be matched precisely to the needs of each job. And in this, Robertshaw-Bridgeport looks to its suppliers for creative technical services. For many years, The American Brass Company specialists have been helping to select the correct alloys in phosphor bronze or brass and to meet fabrication problems in the making of bellows—to apply economically precision-made capillary tubing and other small-diameter copper tube in sensor assemblies. Through such services, The American Brass Company is constantly helping metal fabricators across the nation control quality while keeping costs down.

ARE you caught between cost reduction and quality control? Find out if you are buying metal properties you don't need. An Anaconda specialist may be able to suggest a lower cost alloy that fits the requirements of your job more closely. Or he may find that an adjustment of temper or a change in your fabrication methods can cut your costs. The services of Anaconda specialists are available through your American Brass representative. Call him in today, or write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 5857

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Materials
in Design Engineering. *formerly Materials & Methods*

Selection & use of metals, nonmetallics, forms, finishes

FEBRUARY 1959
VOL. 49, NO. 2

FEATURES

Why and Where to Use Carbide-Base Cermets ..... *W. W. Wellborn* **79**
Advantages and limitations of cermets based on tungsten, chromium and titanium carbides

Explosives Form, Fasten, Engrave, Test ..... *H. P. Tardif* **82**
High deformation rates simplify many fabricating operations. A roundup of present applications

New High-Purity Aluminum Coatings ..... *J. Utz, S. Kritzer* **88**
Coatings for corrosion resistance or electrical insulation can now be produced by electrodeposition

Six Precautions in Using High Strength Steels ..... *E. A. Loria* **90**
Steels heat treated to high strengths need special attention in designing for lightweight structures

Polyester Film—How Long Does It Last? ..... *W. McMahon et al* **94**
Design curves show useful service life of Mylar at various temperatures and humidities

Adhesive Bonding of Titanium ..... *H. E. Pattee et al* **96**
Problems involving adhesives and special surface treatments seem to be nearing solution

New Wrought Iron Has Better Corrosion Resistance ..... *E. P. Best* **100**
Replacing the old, familiar grade, this iron seems to offer 25% more resistance to corrosion

MANUAL NO. 156

Engineer's Guide to Plastics ..... *M. W. Riley* **103**
For the engineer new to plastics: a 16-page article comparing the 19 major groups of materials

DEPARTMENTS

MATERIALS AT WORK **7**
At a Glance—*7*. New Uses for Polypropylene—*10*. End Welded Studs Fasten Ultrasonic Tank—*11*. Vessels Lined with Tantalum—*12*. Other Contents—*12*.

TECHNICAL LITERATURE **38**
Suppliers' New Bulletins—*38*. Books—*214*. Reports—*218*.

FILE FACTS **121**
Properties and Uses of Electroplates

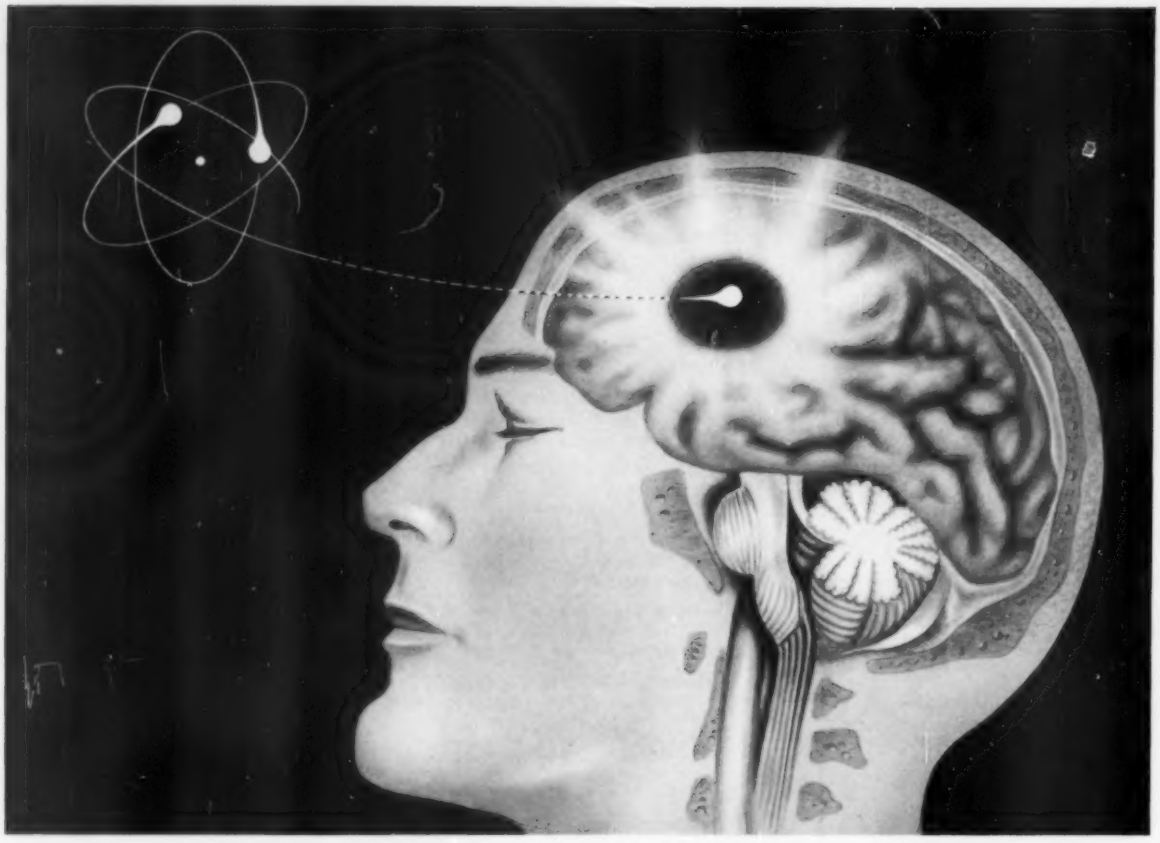
WHAT'S NEW IN MATERIALS **123**
At a Glance—*3*. Quartz-Reinforced Plastics Strong at 5000 F—*123*. Clear Resin Has Good Weatherability—*124*. High Strength, Low Alloy Steels—*125*. Plastics Show: New Molding Resins, Sheets, Films—*126*. Other Contents—*126*.

PRICES AND SUPPLY—AT A GLANCE **195**

NEWS OF INDUSTRY **197**
New Technical Society—*197*. Seminars Set on Gray Iron, Epoxy Tools—*198*. News of Engineers—*202*. Companies—*206*. Societies—*208*. Meetings—*212*.

OTHER DEPARTMENTS
Letters—*14*. Reader Service—*35*. Advertisers: *220*, Product Index—*37*. Last Word—*222*.

COVER BY HARRY & MARION ZELENKO



Neutron-sensitive isotope made in Monel fractionator

Boron-10 vs. brain tumors

Physicians and scientists working in cancer research at Brookhaven National Laboratory, Upton, N. Y., are probing the use of Boron-10 isotope in treating a common type of brain tumor *(glioblastoma multiforme)*.

Results of this therapy are so encouraging that Brookhaven and at least two other institutions are constructing additional nuclear reactors used in this therapeutic venture.

The method. In a technique known as Neutron Capture Therapy, the patient receives an injection of a Boron-10 compound. Cancerous tissue absorbs Boron-10 more rapidly than healthy tissue. While the isotope is concentrated in the tumor, neutrons from a nuclear reactor are beamed at it. The Boron-10 in the cancer absorbs most of the neutrons.

In the split second that the Boron-10 becomes radioactive, it produces short-ranged alpha particles which destroy cancerous tissue with a minimum of damage to healthy tissue.

Producing the isotope. The plant furnishing Boron-10 to Brookhaven ordinarily turns out about three pounds during a 24-hour work day. Separation of the isotope takes place in what is described as "the world's most efficient fractionating system." In 350 feet of total height, six series-connected Monel* nickel-copper alloy columns enrich a complex containing 18.8% Boron-10 isotope to one containing 92% Boron-10.

Corrosive action foiled. Throughout subsequent manufacturing processes, where equipment is constantly subject to fluoride attack, only pure Nickel or Monel alloy is used. These metals hold corrosion at arm's length in columns, reboilers, condensers, vessels, pumps, and piping.

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What's new IN MATERIALS

...AT A GLANCE

Steel bars having higher strength and better uniformity than cold finished bars have been made by a new technique called "elevated temperature drawing" (a modification of cold drawing in which the bar is worked in the 200 to 1200 F range). The bars are said to retain the dimensional tolerances, surface finish and machinability that make cold drawn bars superior to hot finished materials. As a result, carbon steel bars can be used without heat treatment for parts formerly requiring heat treated alloy steel. (More details next month.)

Source: La Salle Steel Co., P. O. Box 6300-A, Chicago 80.

A new corrosion and heat resistant stainless steel with low nickel content (3 to 5%) withstands temperatures up to 1600 F. It is nonmagnetic and is easy to weld. Heat treated properties: 162,000 psi tensile strength, 102,000 psi yield strength (0.2% offset), 9% elongation (2 in.), and 344 Bhn. The alloy is recommended for steam valves, gas turbine parts, roller bearings and chemical process equipment. (More details next month.)

Source: Armco Steel Corp., Middletown, Ohio.

Fabrication of hard-to-form materials such as pure tungsten, molybdenum, zirconium and tantalum, can be done by using a plasma arc torch that operates at controlled temperatures up to 30,000 F. Solid materials are passed through the torch, carried out as a fluid by inert gases flowing at speeds up to 10,000 mph, and deposited on a form that is subsequently dissolved in acid. The torch can also be used to coat virtually any material. (More details next month.)

Source: Linde Co., Div. of Union Carbide Corp., 30 E. 42nd St., New York 17.

Cermet shapes can be formed by using a special flame-spray gun that propels molten particles against a disposable form with high air pressure. The method has been used to form chromium carbide, molybdenum disilicide, nickel aluminide, chromium-nickel boride, tungsten-boron compounds and molybdenum aluminide. The gun can also be used to deposit cermet coatings. (More details in a forthcoming issue.)

Source: Firth Sterling, Inc., American Electro Metal Div., Yonkers, N. Y.

A weldable, hardenable 12% chromium steel is being marketed in the form of bar, wire, strip and forgings. The alloy, said to be free from weld cracking without preheating or postheating, shows a marked improvement in weldability over type 410 stainless steel. According to the developer, the alloy can be used continuously at temperatures up to 1200 F. It will probably find use in steam turbine buckets, blades, covers and diaphragms. (More details in a forthcoming issue.)

Source: Carpenter Steel Co., Reading, Pa.

TFE electrical tapes as thin as 1 mil can be produced by using a new grade of TFE fluorocarbon resin (Teflon 7). Previously, the thinnest electrical tape of TFE was 2 mils. The TFE molding and extrusion powder can be fabricated into very

What's new IN MATERIALS

thin sections because it is granulated to ultra-fine particle size. Other uses for the resin include tank linings, gaskets and diaphragms. (More details next month.)
Source: E. I. du Pont de Nemours & Co., Inc., Polychemicals Dept., Wilmington 98, Del.

Direct casting of molybdenum metal has been accomplished by the Bureau of Mines. The Bureau's casting method, details of which have not been revealed, has been used successfully to cast hollow molybdenum parts. Usually hollow forms of this metal are made by powder metallurgy techniques.
Source: Bureau of Mines, Dept. of the Interior, Washington 25, D. C.

A magnesium sheet and plate alloy does not require stress relief after welding. The new material, which contains zinc and rare earth metals as alloying elements, has 38,000 psi tensile strength, 28,000 psi yield strength and 26,000 psi compressive strength. It is recommended for tank trailer bodies, and for large shipping containers. (More details next month.)
Source: Dow Chemical Co., Magnesium Dept., Midland, Mich.

Stronger metals for high temperature service have come out of a new "melt-saturation" technique in which minute ceramic particles are uniformly dispersed in molten metal. The technique has produced ceramic-alloyed copper that is three to four times as strong as conventional copper at 1800 F, and ceramic-alloyed aluminum that is at least three times as strong as conventional aluminum at 1000 F. The ductility loss of ceramic-alloyed copper is approximately 30 to 40%.
Source: Denver Research Institute, University of Denver, Denver 10, Colo.

A new high strength aluminum casting alloy handles about the same as alloy 356, but has considerably higher mechanical properties. In the T6 condition the alloy has 49,000 psi tensile strength, 36,000 psi yield strength and 8% elongation.
Source: Reynolds Metals Co., Richmond 18, Va.

High quality copper strip made from powder is now in pilot plant production. The new strip is said to be considerably cheaper (about 80%) than electrolytic grade strip. It also has higher tensile strength (40,000 psi) and lower oxygen content (0.020%) than electrolytic-grade strip (35,000 psi and 0.040% respectively). Copper powder strip is made by a continuous process in which powder is compacted, sintered and hot rolled.
Source: E. W. Bliss Co., Rolling Mill Div., Salem, Ohio.

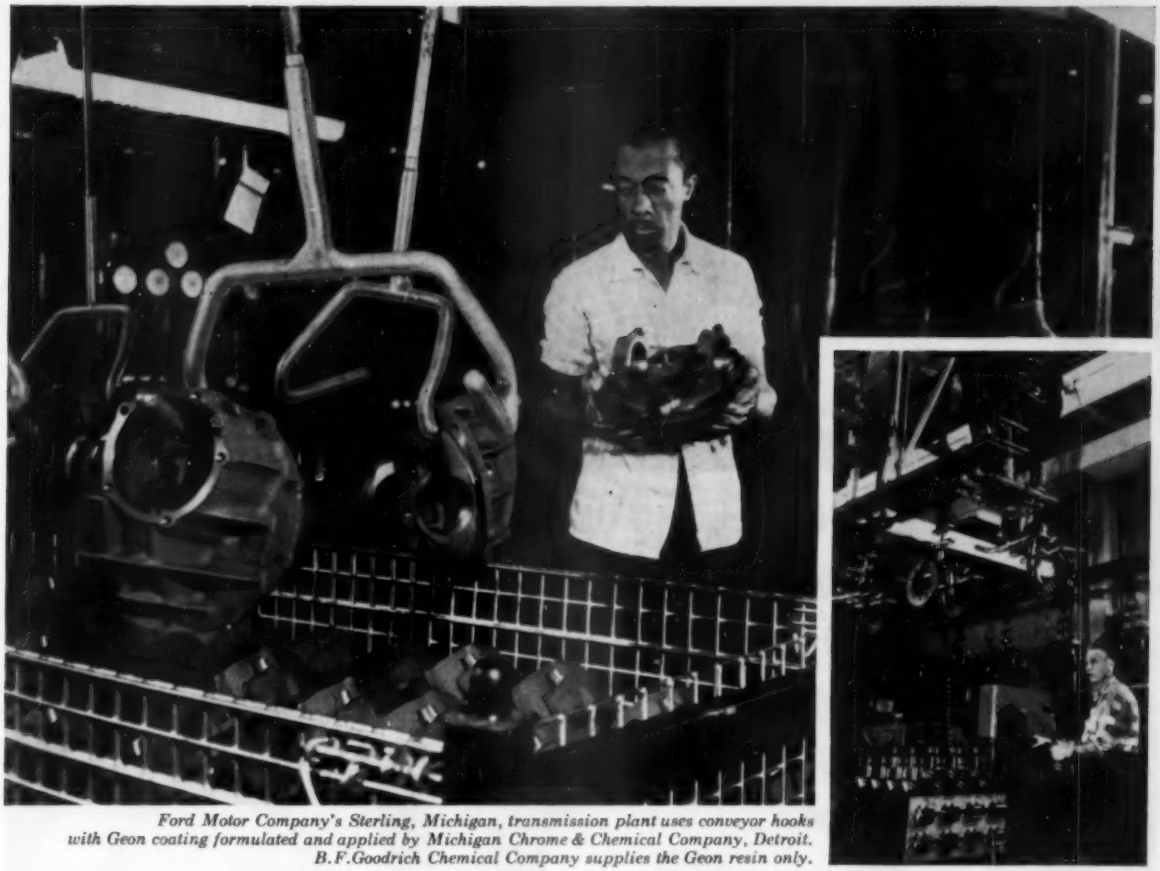
A new series of steels for use in nuclear power plants has been developed. The steels have a chemistry considered to be a radical departure from that of standard steels. They can be produced in the form of plate, sheet, strip, bars, tubing, rods, wire and extruded shapes, and can be welded and fabricated by conventional methods. (More details in a forthcoming issue.)
Source: Jones & Laughlin Steel Corp., 3 Gateway Center, Pittsburgh 30.

A lightweight iron-aluminum-manganese alloy keeps its strength at temperatures up to 1200 F. The new alloy combines good cold workability with good oxidation resistance. The material is said to be about 15% lighter than carbon and 18-8 steels and about 25% lighter than nickel-base alloys.
Source: National Research Corp., 70 Memorial Dr., Cambridge 42, Mass.

Turn to page 123 for more "What's New in Materials"

Another new development using

B.F.Goodrich Chemical *raw materials*



Ford Motor Company's Sterling, Michigan, transmission plant uses conveyor hooks with Geon coating formulated and applied by Michigan Chrome & Chemical Company, Detroit. B.F.Goodrich Chemical Company supplies the Geon resin only.

"Soft touch" of Geon safeguards parts quality

The overhead conveyor system in this automatic transmission plant uses 26,000 hooks coated with Geon polyvinyl material. The soft yet durable coating made from Geon protects finished parts while they are carried from machining to assembly stations.

In addition to giving the hooks a long and profitable service life, the Geon coatings come in any color, permitting color-coding for multiple conveyor operations.

Versatile Geon is ideal for many coating applications, since it disperses readily in the coating formula. Geon can be used to coat paper, textiles, metals or almost any material to provide new or improved advantages. Hundreds of types of Geon resins, plastics, latices and polyblends are available, tailored to specific uses for coatings, moldings, extrusions, or rigid or foam applications. For information, write Dept. LP-1, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

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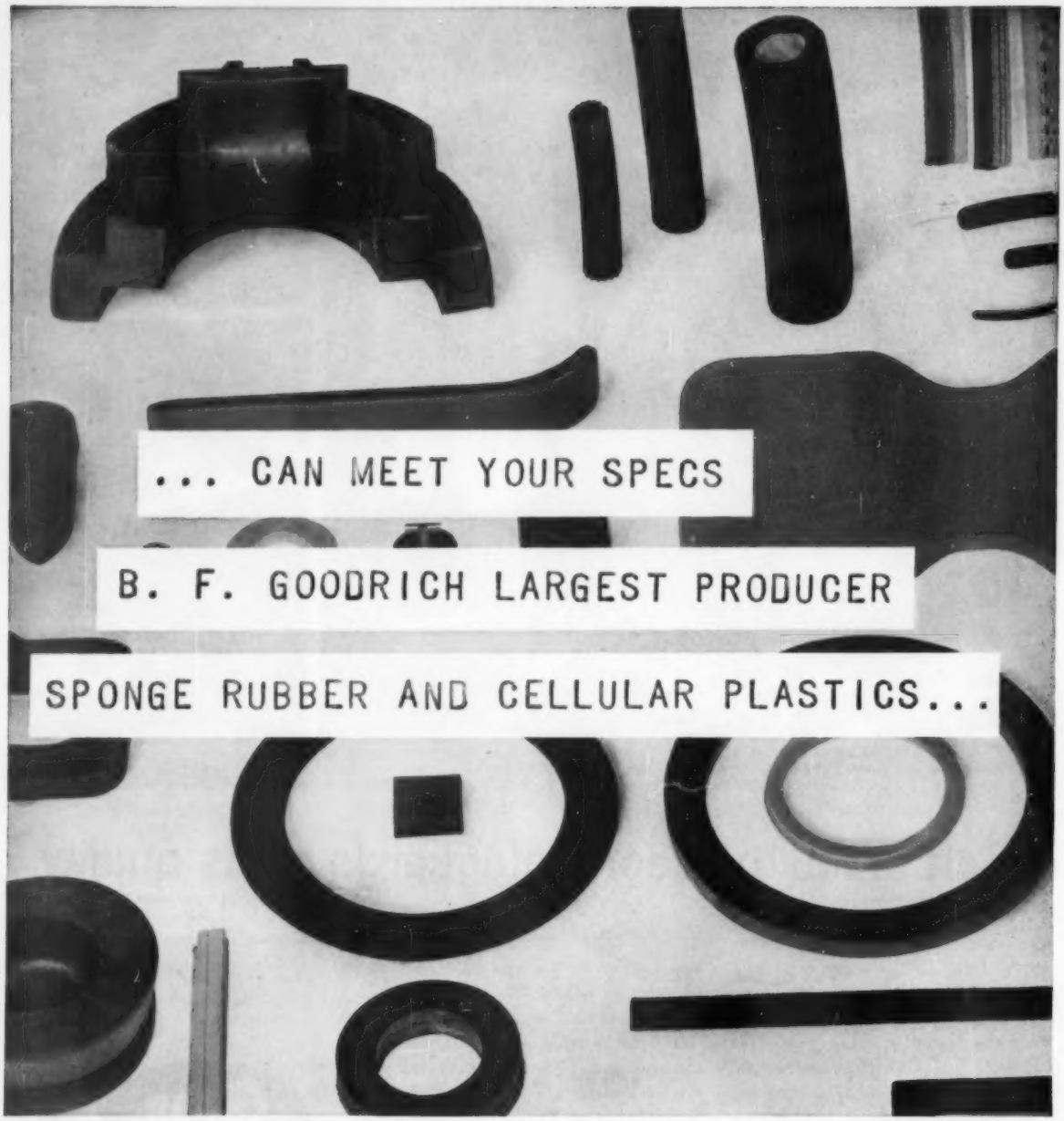

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MATERIALS AT WORK

...AT A GLANCE

Acrylic filter cuts cost of producing titanium

Excellent wet strength, resistance to chemicals, and the ability to retain an open weave are the reasons given for the selection of Dynel (acrylonitrile copolymer) filter cloth for use in the production of titanium sponge. The filter cloth is used to hold the titanium sponge while it is being spin-dried in a centrifuge at speeds up to 500 rpm. The Dynel cloth not only doesn't deteriorate when exposed to the various acids present in the wet sponge, but actually retains its strength and shape after 25 days of repeated wetting and drying processes; a previously used material had to be replaced daily.

Source: Union Carbide Chemicals Co.; cloth woven by National Filter Media Corp.; titanium sponge by Electro Metallurgical Co.

Hard surfaced pump sleeve outlasts steel

The change from type 316 stainless to hard surfaced carbon steel has resulted in a better than 3 to 1 increase in the life of sleeves used in crude oil pumps. The previously used stainless steel sleeve became unusable after only 105 days. The hard surfaced sleeve, consisting of carbon steel overlaid with a nickel alloy powder containing chromium borides and chromium carbides, was still usable after 13 months.

Source: Wall Colmonoy Corp.

Urethane foam insulation snaps on pipes

Pipelines and fittings can now be thermally insulated with lightweight, flexible urethane foam which is simply snapped into place. The insulation, supplied in preformed sections containing only one seam, is said to have a low *k* factor, excellent resistance to physical damage and "unusual resistance to chemicals and solvents." The insulation is available with either a factory-applied moisture vapor barrier or a felt paper jacket for outdoor use.

Source: Allied Chemical Corp.

Zinc die casting replaces four machined parts

A single zinc die casting has replaced four parts previously used in an electrical switching device—at a saving of 50% in production and materials costs. The four parts previously used—two brass screw machine parts and two steel stampings—required machining, drilling, reaming, stamping and punching. With the zinc die casting, only trimming and tapping three cored holes are necessary.

Source: American Zinc Institute; part used by Chicago Coin Machine Div., Chicago Dynamic Industries.

Graphite blocks hold panels in brazing

The largest blocks of graphite ever made—20 x 46½ x 116 in.—are presently being fabricated into huge forms to hold stainless steel honeycomb panels in brazing furnaces. Because of its very low thermal expansion, "graphite has proved to be the only acceptable material to support the large panels and hold their extremely accurate dimensions," the supplier says. In addition, graphite can be precisely machined to the intricate shapes and contours required.

Source: National Carbon Co., Div. of Union Carbide Corp.

Sapphires are efficient valve poppets

Extreme hardness, chemical resistance, high temperature strength, dimensional accuracy and polished

(continued on p 9)

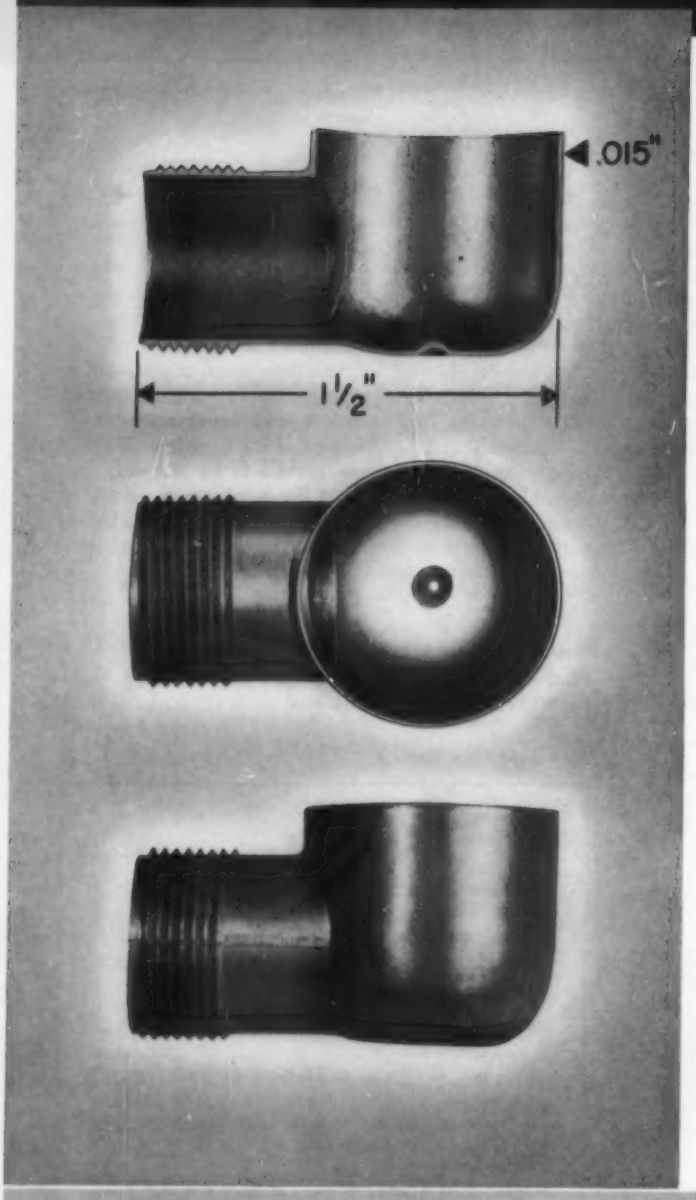
Briefs

Permanent magnets as small in diameter as a human hair are being made from an alloy of copper, nickel and iron. The magnets are expected to find use in components of magnetometers and galvanometers.

Polyethylene tubing has replaced the traditional bucket-and-carry system of gathering maple sap. From 30 to 60 taps are now grouped in a single collection line which empties into a large storage tank. And the sap is said to flow and taste better.

Paper-thin slabs of pure silicon are the basis of a new electronic device that promises an inexhaustible power supply for hearing aids. The device, mounted on the temple bar of eyeglass hearing aids, is said to be so sensitive that it operates in ordinary daylight and lamplight; in darkness, the regular battery is automatically turned on.

IT'S LIGHTER THAN YOU THINK!



AND STRONGER, TOO, WHEN DIE CAST with ZAMAK

This thin-wall spark plug shield is a zinc die casting with minimum wall thickness of only .015".

Many zinc die castings are as thin as stampings, yet can be produced in shapes that cannot be duplicated as one-piece stampings.

More and more, engineers are learning that they can design parts for ZAMAK alloy die casting that will compete with either steel stampings or castings of the lightweight metals—and at lower cost.

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surface are the reasons given for the selection of sapphire balls for valve poppets used in assemblies designed to relieve pressure. In operation, the sapphires are required to withstand continual hammering against a hard metal seat while maintaining very low leakage over an extremely wide temperature range. The sapphires are available in the shape of domes and windows up to 4½ in. in dia and in special configurations.

Source: Linde Co., Div. of Union Carbide Corp.

Wrought iron specified for boiler house

Excellent corrosion resistance, and hence the elimination of pipe failure, is the reason given for the selection of wrought iron for a piping system used in a new boiler house. The piping system, which is used to handle steam, condensate and water, is composed completely of wrought iron, including all fittings. Approximately 15-20 tons of the wrought iron piping are used.

Source: A. M. Byers Co.; piping system used in Loyola College.

Vulcanized fibre spring solves design problem

Vulcanized fibre has proved more suitable than steel for springs to hold wires in place in fluorescent lighting fixtures. Originally, wires were manually tied into cables. To eliminate this time consuming operation, steel springs were specified. However, several of the springs snapped during installation and made assembly extremely dangerous. The use of nonshattering vulcanized fibre not only solved the problem, but resulted in a substantial reduction in materials costs as well.

Source: National Vulcanized Fibre Co.

Steel dump trucks now weigh less

The change from mild carbon steel to high strength, low alloy steel has resulted in a 25% weight reduction in the design of dump truck bodies. The high strength, low alloy steel was selected because its greater strength allows thinner sections to be used. In addition, it is resistant to corrosion, abrasion and impact.

Source: Jones & Laughlin Steel Corp.; truck bodies manufactured by Moore Body Co.

Extruded nylon cam replaces steel

The switch from steel to extruded nylon for traverse cams used on thread winding machines has resulted in reductions in maintenance costs, power consumption and noise level, and an increase of 20-30% in machine output. The switch was originally specified particularly to reduce noise level. However, the nylon cam's light weight—1½ lb as compared to 5 lb for the steel—allows faster operation of the machine at less power. In addition, the nylon cam does not require lubrication.

Source: Polymer Corp. of Pa.; cam used by Abbott Machine Co.

(more Materials at Work on next page)

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Polypropylene now used for . . .

Since its introduction a little over a year ago (see M/DE, Dec '57, p 164 and Jan '58, p 110), polypropylene has emerged from an interesting new development to an important new engineering material. Several companies are now producing the material in commercial quantities, and the list of applications is expected to grow.

The primary reason for polypropylene's acceptance is the excellent combination of properties it offers: high heat resistance (melting point ranges from 325 to 340 F); good strength, toughness and chemical resistance; and good dielectric properties. The accompanying photos indicate the variety of uses for which the material is suited.

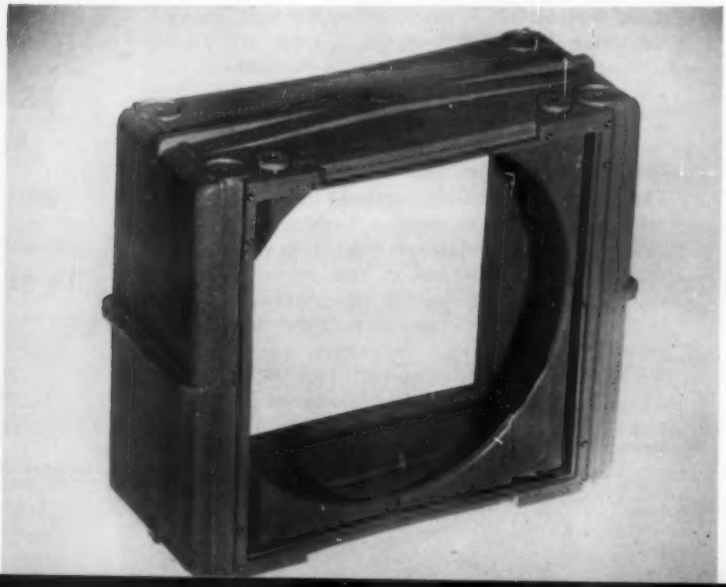
Edited by Walter Lubars

Shock absorbers *because it has good rigidity and toughness.*

Valves and fittings *because it is resistant to chemicals and heat, and can be easily molded or extruded to close tolerances.*

Sanitary products *because it is sterilizable and resistant to acids, alkalies and solvents.*

Housings *because it has good dielectric properties, rigidity and strength.*
Montecatini Chemical Co.



End welded studs fasten ultrasonic tank

The use of end welded studs has solved the difficult problem of fastening rapidly vibrating elements (20,000 times per sec) to ultrasonic processing tanks.

According to Nelson Stud Welding Div., Gregory Industries, Inc., the decision to use studs came after several other methods proved unsatisfactory: epoxy cements were tried first, but deteriorated; rivets loosened and leaked; and hand welding around rivets caused distortion and pitting, which in turn necessitated extensive machining to restore surfaces.

Five type 304 stainless steel studs are used to secure each element (which is a solid block of metal 2 in. in cross section and 4½ in. long) to a stainless steel tank. The studs are easily welded through pre-drilled holes with a semi-automatic stud welding gun (see photo at left).

Graphite-filled nylon replaces roller bearings

The switch from standard roller bearings to an oil-sintered, graphite-filled nylon bearing has resulted in increased life and improved efficiency for sliding door hangers (see photo at right).

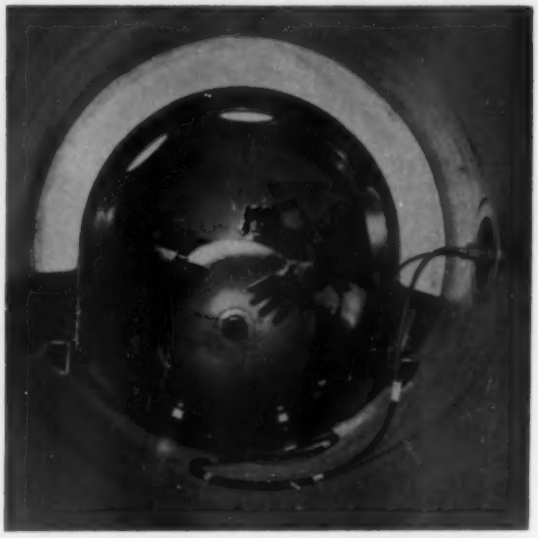
According to Starline, Inc., the switch was made to: 1) minimize frictional drag on the bearings; 2) maintain lubrication on the bearing shaft for an extended time; 3) prevent "corrosive wear" on the hanger guide plates; and 4) extend life of the bearing.

Four other materials were tested: sintered bronze, sintered iron, molded nylon, and molded graphite-filled nylon. The oil-sintered, graphite-filled nylon was superior because it exhibited less wear and has a lower cofficient of friction. In addition, the part retains oil indefinitely, thus eliminating the need for lubrication.

Polymer Corp. of Pennsylvania

Tantalum-lined vessel was made in . . .

. . . special vacuum chamber



Tantalum-lined vessels

Use of tantalum for corrosion resistance applications has been given added impetus with the successful development of what is said to be the largest tantalum-lined reactor vessel ever made.

The vessel, jointly developed by Haynes Stellite Co., Div. of Union Carbide Corp., and Pfaudler Co., is a 30-gal unit designed to operate at 650 F and 500 psi. The reactor chamber consists of a 0.030-in. tantalum liner with a ⅝-in. outer shell of type 430 stainless steel. All surfaces of the chamber that contact the product being processed are tantalum, including a tantalum-sheathed agitator shaft, solid tantalum agitator and baffle, and a tantalum immersion-type bayonet heater. Total vessel weight (without drive mechanisms) is approximately 700 lb.

To fabricate the vessel, a special "vacuum purge" welding unit was used, since tantalum combines readily with oxygen, nitrogen and hydrogen. The unit consists of a specially constructed tank 42 in. in dia and 11 ft long. Inert-gas tungsten arc welding is used.

Inorganic insulation protects motor at 1000 F

The experimental motor shown in the photo below was operated for more than 1000 hr at a temperature of 950 F. Purpose: to test the performance and heat resistance of a new system of electrical insulation that may prove valuable in supersonic jets, missiles, rockets and other high speed aircraft.

According to Westinghouse Electric Corp., the new inorganic insulation system consists of four basic components: phase insulation, slot insulation, wire insulation and a potting and impregnating compound. The phase and slot insulation is a flexible sheet material consisting of glass cloth and large mica flakes bonded with phosphate. The wire insulation consists of glass fibers impregnated with a suspension of powdered mica in a phosphate solution. (The wire remains flexible and can be wound into the motor in a

(continued on p 180)

MORE MATERIALS AT WORK

All-aluminum car in 1960?.. 180
Strippable butyrate cuts plating costs 182
Reinforced plastics used in acid tank 184
Heated drive-ins 184
Ductile iron castings..... 186
Precision insulators 188
Beryllium copper latch..... 190
Kel-F replaces metal in potentiometer parts 190
Glass-phenolic clutch 192

RCI EPOTUF Epoxy Resin

"An ideal resin for potting applications"

says J. R. McRobert, vice president, Novi Equipment Company

Engine heat, vibration and road shocks present problems that must be met and mastered in auto air conditioning equipment. And the Novi Equipment Company, Novi, Michigan, has found that an RCI EPOTUF epoxy resin plays a vital role in the manufacture of its air conditioners — successfully seals a copper coil component in the steel magnetic compressor clutch — insuring dependable performance.

"The use of EPOTUF allows a very close tolerance with a permanent, rigid seal that prevents copper-steel contact — and the 'shorting out' that would thereby result," explains Mr. McRobert. "EPOTUF is the ideal resin for our purposes, possessing excellent qualities of adhesion with the exact electrical properties we require."

Manufacturers everywhere are finding increased use for Reichhold's versatile epoxy resins. EPOTUF epoxies offer rugged strength, corrosion resistance and superior bonding properties that have proven perfect for a variety of applications.

And when you do business with RCI, you can count on fast, on-time deliveries anywhere in the country. Why not let *us* know *your* epoxy requirements?

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Synthetic Resins • Chemical Colors • Industrial Adhesives • Phenol
Hydrochloric Acid • Formaldehyde • Glycerine • Phthalic Anhydride • Maleic Anhydride
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Creative Chemistry...
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From Pattern to Machined and Tested Parts by FRONTIER
Nickel-bronze pressure vessel for service at elevated temperatures and pressures. Cast, machined and tested by Frontier Bronze.
COMPLETE RESPONSIBILITY IN ONE SUPPLIER

Castings shown are typical of FRONTIER complete service to equipment builders. Certified chemical, physical and X-Ray tests, made in our own laboratory, can also be furnished if requested. Frontier is a complete, modern, non-ferrous foundry where castings often considered impossible become routine under the skillful direction of our foundrymen and metallurgists.

Call in a Frontier Metallurgist at the design stage of any new product. You will find him of invaluable aid not only in selecting alloys that will give the desired results, but in making design recommendations that will lead to better, more economical castings. Let us solve your non-ferrous casting problems.

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Paul Bergsoe & Son, Glostrup, Denmark
L'Aluminum Francais, Paris, France

For more information, turn to Reader Service card, circle No. 367

Additional Rene 41 suppliers

To the Editor:

May I call your attention to the news article on René 41, Nov '53, p 143. This article erroneously implies that there are only two producers of this material. Universal-Cyclops Steel Corp. has produced and shipped significant quantities of this material in bar, sheet and billet form. We are also one of the few producers in the high temperature metals industry who have completely integrated facilities for all types of vacuum melting (Duomelt, Inductovac and Duovac) and the fabrication into mill products of René 41 and similar alloys . . .

C. CLEMENT ENGLISH, JR.
Manager High Temperature Metal Sales
Universal-Cyclops Steel Corp.
Bridgeville, Pa.

. . . We, too, are engaged in the production and sale of René 41 alloy. Haynes Stellite Co. is accepting orders for the alloy in the form of sheet, bar, wire and forging stock.

D. L. JEKA
Haynes Stellite Co.
New York, N. Y.

Information on other companies producing this alloy is given on p 166 of this issue.

Magnetic rubber

To the Editor:

Inquiries have been directed to me concerning a magnetic rubber compound. It is believed this material has a trade name of "Denmag" (or a similar name). I have been unable to find such a material anywhere and would appreciate any information.

THOMAS E. BAKER
Production Engineering Dept.
Raytheon Mfg. Co.
Maynard, Mass.

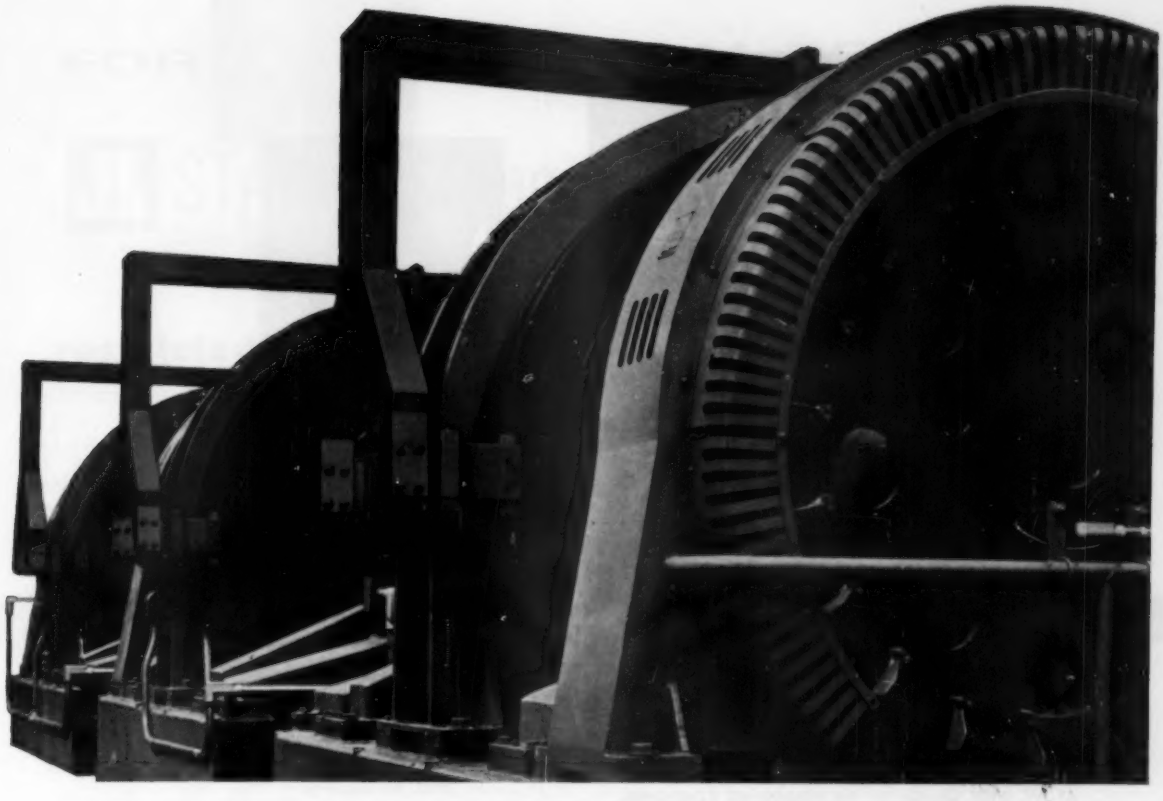
Our readers may be able to help.

Porous bearings — an objection . . .

To the Editor:

Your article "Selecting Sleeve Bearing Materials," Oct '58, p 119, covered an extremely broad field, and was of great interest. There is one point on which your findings were somewhat at variance with the values published by the SAE and the ASTM, as well as test results obtained here at Amplex.

Specifically, you mention a PV limit of 20,000 for porous metals, in comparison with the figure of



REVERE COPPER BUS BAR

used in two new 700-ft. long Udylite Bumper Plating Machines at

FORD MOTOR COMPANY

Aids in the production of a new, more durable, corrosion-resistant finish

Said to be the world's largest, the two Udylite plating machines are capable of turning out, per machine, 35 racks of bumpers an hour through 10 stages of a 3½ hour plating cycle. The electro-plating installation uses eighty generators, varying from 5,000 to 20,000 amps, which combined, provide enough power to light more than 150,000 bulbs of 100 watts each.

To carry that kind of a load from generator to plating machine, Revere Copper Bus Bar was used because of copper's superior electrical and heat conductivity. No other commercial metal of the same cross-section area approaches electrolytic copper in its ability to carry electricity, while its high thermal conductivity offers the greatest ease of cooling. This means a more compact installation with a resultant saving in space. Also, joints of high electrical conductivity are readily made by soldering, brazing or bolting. For information on Revere Bus Bar, as well as other Revere copper and brass mill products consult the nearest Revere Sales Office. You'll find it listed in the yellow pages of the telephone directory.

REVERE COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

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Mills: Rome, N.Y.; Baltimore, Md.; Chicago, Clinton and Joliet, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Brooklyn, N.Y.; Newport, Ark.; Ft. Calhoun, Neb. Sales Offices in Principal Cities, Distributors Everywhere.

RACK OF BUMPERS ready for immersion into plating solution at Ford Motor Company's plant at Monroe, Michigan. New process uses copper, white brass, nickel and chromium which results in outstanding durability.

For more information, turn to Reader Service Card, circle No. 459

share a mold–divide the cost

AT ATLANTIC CASTING

Typical Atlantic Production Mold-Half (18" x 12")

PRODUCTION COSTS FOR PRECISION CASTINGS SHOWN ABOVE WERE SHARED BY THE FOLLOWING COMPANIES:

General Electric Company; Intertype Corporation; Westinghouse Electric Corporation; Air Reduction Corporation; United Shoe Machinery Corporation; I.T.E. Circuit Breaker Company; Ordnance Corps. Dept. of Army; Vonnegut Hardware Company.

PRECISION CASTINGS COST LESS AT ATLANTIC because production molds are shared by up to fifteen different customers and fifty castings. Standard production molds are produced and poured on a continuous basis and when an order for a casting is completed, the portion of the mold vacated is immediately utilized for another casting, while production proceeds without interruption.

TOOLING COSTS CUT!

Atlantic mold-sharing requires only one inexpensive, brass pattern, quickly produced and easily altered.

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Pouring as many as fifty castings in a single mold allows substantial reduction in labor costs per casting. This saving is passed on to you.

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PRescott 9-2450

For more information, turn to Reader Service card, circle No. 372

50,000 given by the SAE and the ASTM. We have had satisfactory tests at as high as 210,000 PV, though, of course, I don't claim that all porous metal bearings will operate up to this limit under all conditions. This was an 8-hr test on a bearing of nominal 1-in. i.d. x 1¼-in. o.d. x 1½-in. length, vacuum impregnated with an oxidation resistant oil. Clearance was 0.0035/0.004. Loading was radial and unidirectional, at a shaft speed of 1500 rpm. The shaft was of 1010 steel ground to a 12-μin. finish, rms.

EDWARD T. JOHNSON
Amplex Div.
Chrysler Corp.
Detroit, Mich.

. . . and an answer

To the Editor:

My recommendation of the 20,000 PV limit was based largely on approximately 50 life tests with ¼ x ¼-in. and ½ x ½-in. sintered bearings. These room temperature tests were run continuously at speeds of 900 and 1800 rpm with loads of 75, 150 and 300 psi to give PV values of about 9000, 18,000 and 35,000. The shaft material was C1141 steel with hardnesses of both 155 and 320 Bhn, and an F-3 surface finish was used. No additional lubrication was used other than the SAE 40 oil initially provided by the bearing manufacturer.

We concluded from these evaluations that a PV design limit of 50,000 was too high for continuous long-life operation of porous bronze bearings under these test conditions. With a PV of 35,000 with ½ x ½-in. porous bronze at 900 rpm, for instance, life varied from about 10 hr up to 50 hr in 7 tests. Even at 18,000 PV quite a large proportion of bearings failed to run continuously for the 2000-hr period desired.

E. R. BOOSER
AC M&G Engineering Laboratory
General Electric Co.
Schenectady, N. Y.

Resistance-heating plastics?

To the Editor:

Is it true that a new plastics material has been developed that gets hot when an electric current is passed through it, obviating the necessity for heating wires?

ALFRED ROMAN
San Diego, Calif.

Conductive fillers can be used with plastics to obtain some degree of resistance heating but we know of no company doing such work at present. It is being done with various rubbers.

FOR OPTIMUM RESULTS

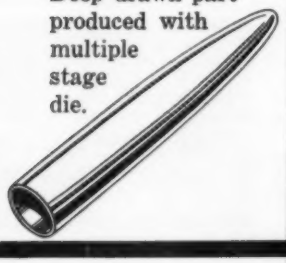
J&L STAINLESS and STRIP DIVISION

restricted specification cold rolled strip steel

Oftentimes, sound selection of cold rolled strip steel should involve more than making a choice of one or more readily available, standard specifications. To achieve best fabricating results, or to improve manufacturing performance and end-product superiority, may require the employment of strip steel specially designed for your particular use. J&L Restricted Specification Strip Steel is that kind of product. As an example look at this . . .

TYPICAL APPLICATION . . .

product	specification	results
Deep drawn part produced with multiple stage die.	Low Carbon Deep Drawing Steel Size—3″ x .010 Analysis—AISI—1010 Temper—Deep drawing, non-scalloping Finish—#2 Tolerance ± .0002 including crown Width Tolerance ± .002 Coil Size—250# per inch width min.	Improved yield. Improved die life. Reduced finishing operations after drawing. Less quality control cost.

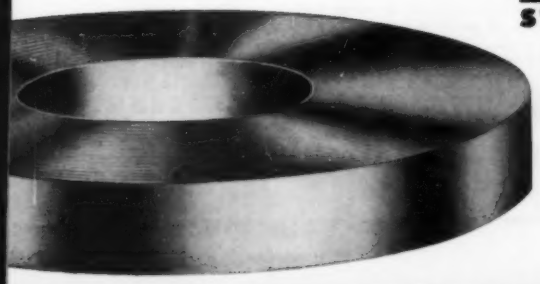


J&L STAINLESS AND STRIP DIVISION produces a full line of restricted and standard specification strip steel in these grades and types:

Low Carbon
Electrolytic Zinc
High Carbon
Alloy
Tempered Spring Steel
Stainless

The experience, facilities and accumulated know-how of a specialized organization devoted exclusively to strip steel processing are available to work with you. In this clearing house of strip steel engineering and application information, it's a good bet there is something of value for you. Your inquiry will get our immediate, interested attention.

STRIP STEEL



Jones & Laughlin
STEEL CORPORATION
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YOUNGSTOWN 1, OHIO

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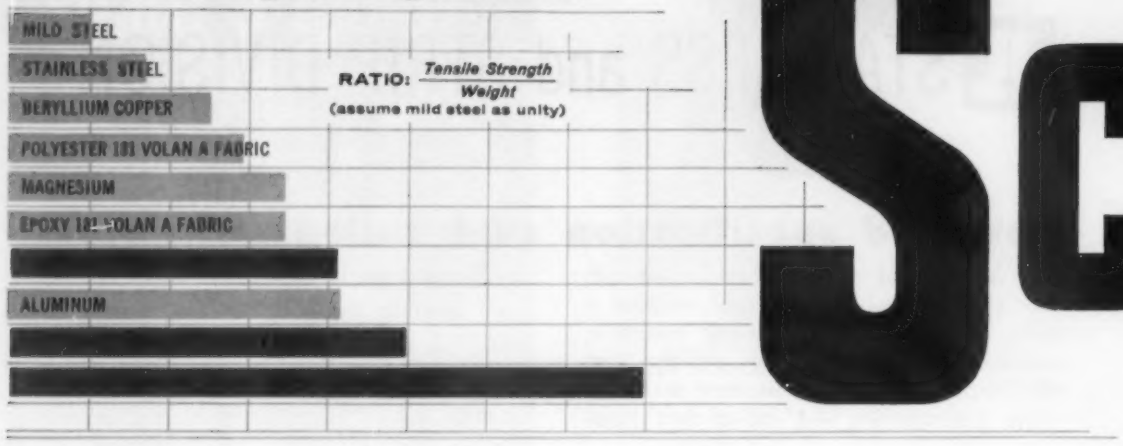
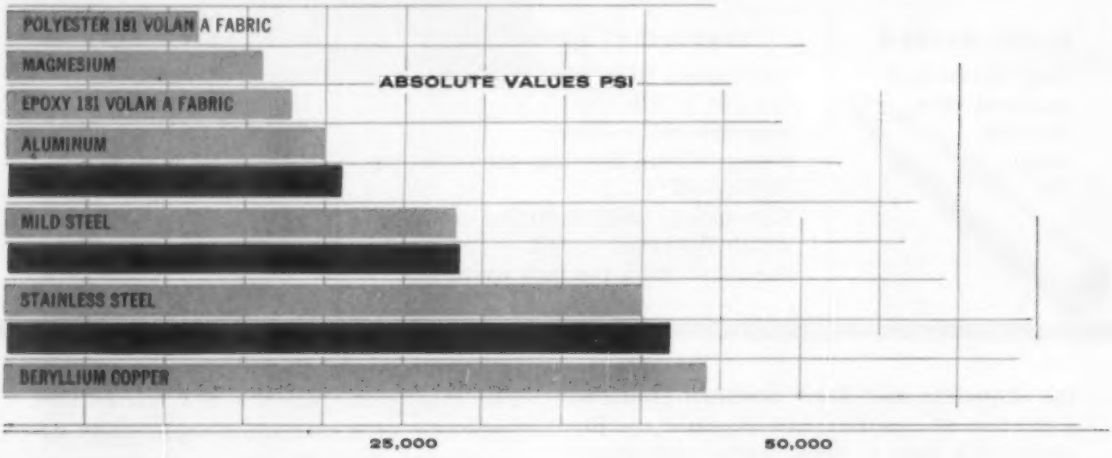
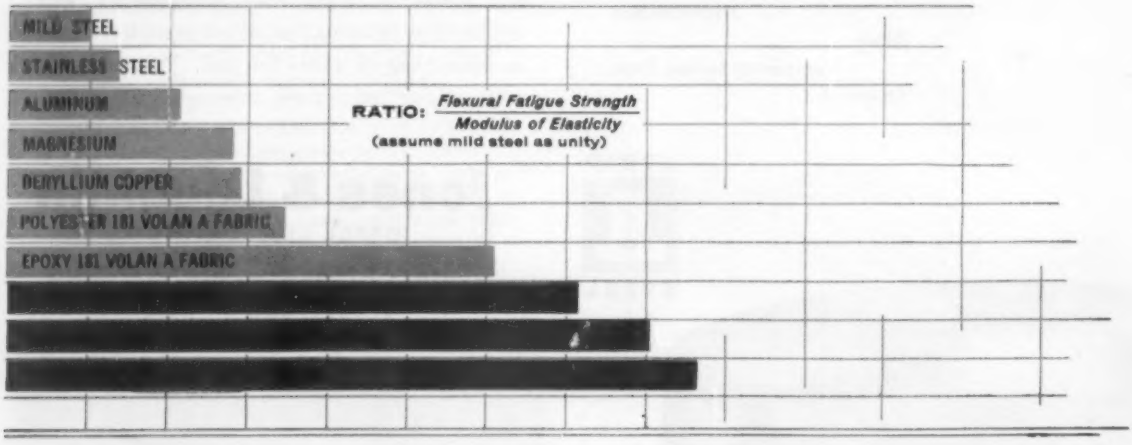
Tensile strength-weight ratios



Flexural-fatigue strength @ 2 x 10^6 cycles



Allowable flexural-fatigue deflection @ 2 x 10^6 cycles



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BRAND **REINFORCED PLASTIC**

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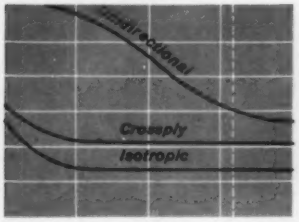
"SCOTCHPLY" flexural-fatigue



Looking for a structural material with a superior strength-weight ratio *and* exceptional fatigue strength? You get it—and more—in "SCOTCHPLY" Brand Reinforced Plastic.

"SCOTCHPLY" Reinforced Plastic is a moldable, laminated plastic reinforced with *continuous non-woven* glass filaments oriented to your specific stress requirements. It is available in epoxy, phenolic and other resin formulations. You get a combination of properties unlike any other structural material on the market.

Compare "SCOTCHPLY" Reinforced Plastic to other structural materials in the graphs on the opposite page. Look at the tensile strength-weight ratios. Then check the fatigue strengths and allowable flexural-fatigue deflections (taken at an arbitrary 2 x 10^6 cycles from the S-N curves shown reduced at left). Valuable combinations? You bet.

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FOR COMPLETE INFORMATION and technical service, write on your letterhead to Dept. PB-29, Reinforced Plastics Division, 3M Co., 1210 University Ave., St. Paul 4, Minn. A "SCOTCHPLY" Reinforced Plastic reference manual will be mailed you without charge.

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Here are some of the reasons why your company can save money and improve product quality . . . by specifying Mueller Brass Co. Cold-Prest Impact Extrusions. Parts are formed with *no chip loss;* you pay only for the metal that goes into the part. Because of the dimensional accuracy of Cold-Prest extrusions, parts can be held to closer tolerances and many costly secondary machining operations are eliminated. They have better physical properties with actually less metal needed to achieve greater strength.

Cold-Prest Impact *extruded parts often reduce or eliminate assembly operations* because products employing several parts can often be made as a single extrusion. Also, complex parts produced by conventional methods requiring costly machining to close tolerances can be made in *A SINGLE OPERATION* as a Cold-Prest extrusion, saving raw material, costs of time, tools and labor . . . as well as assuring a positive leak-proof part.

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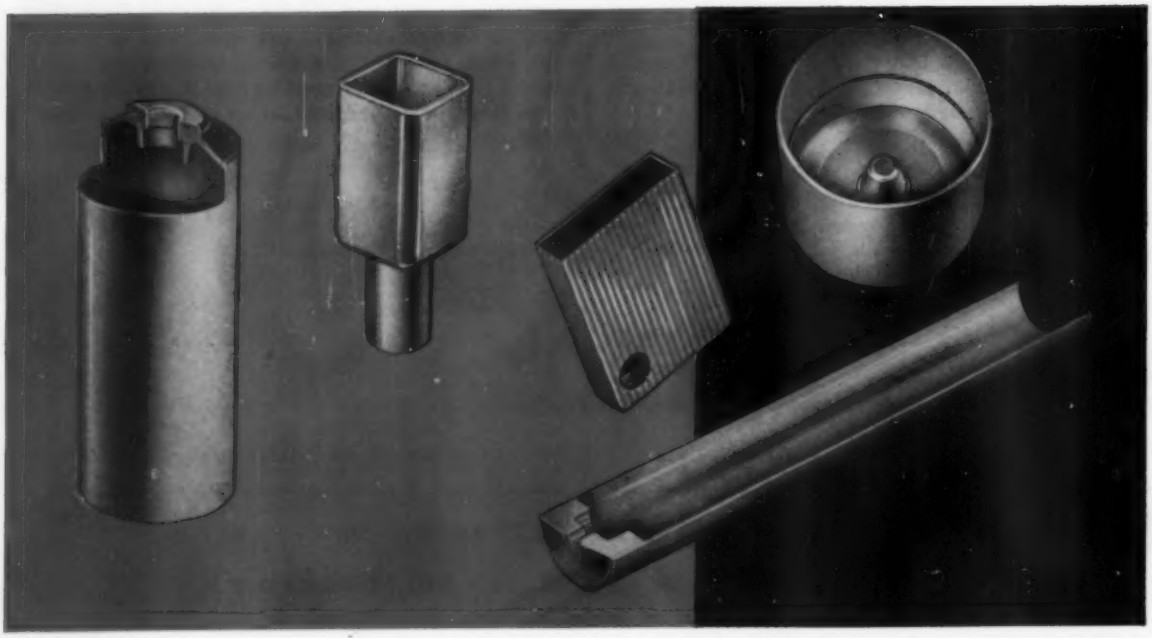

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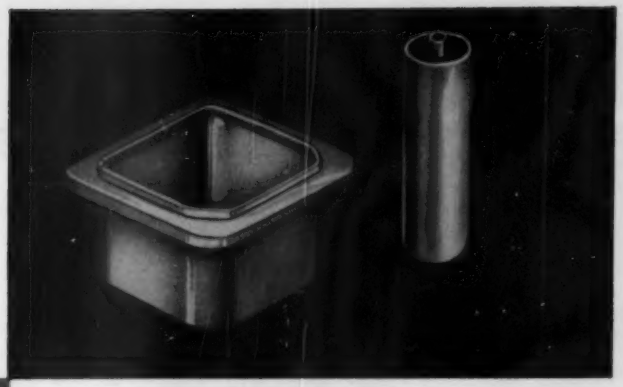
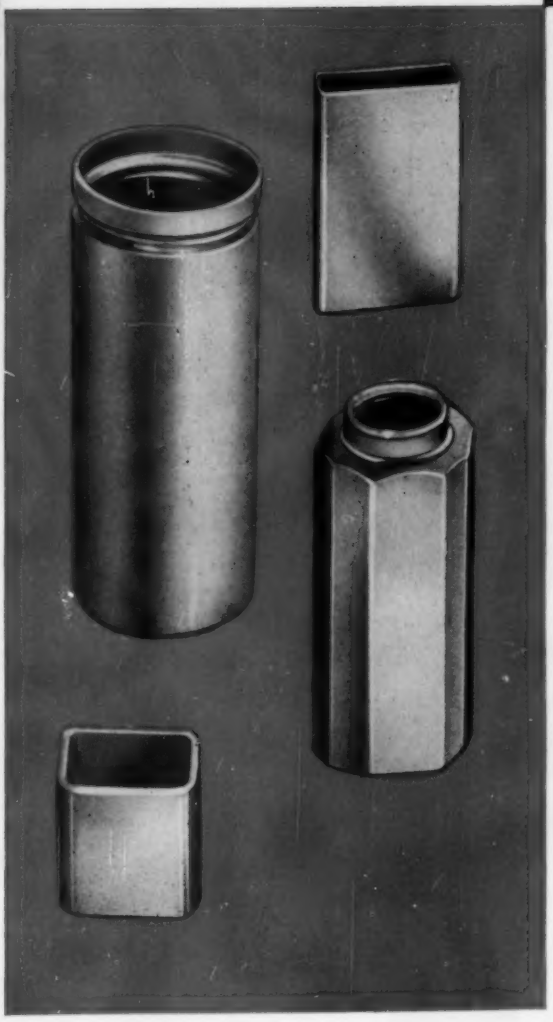
EXTRUSIONS





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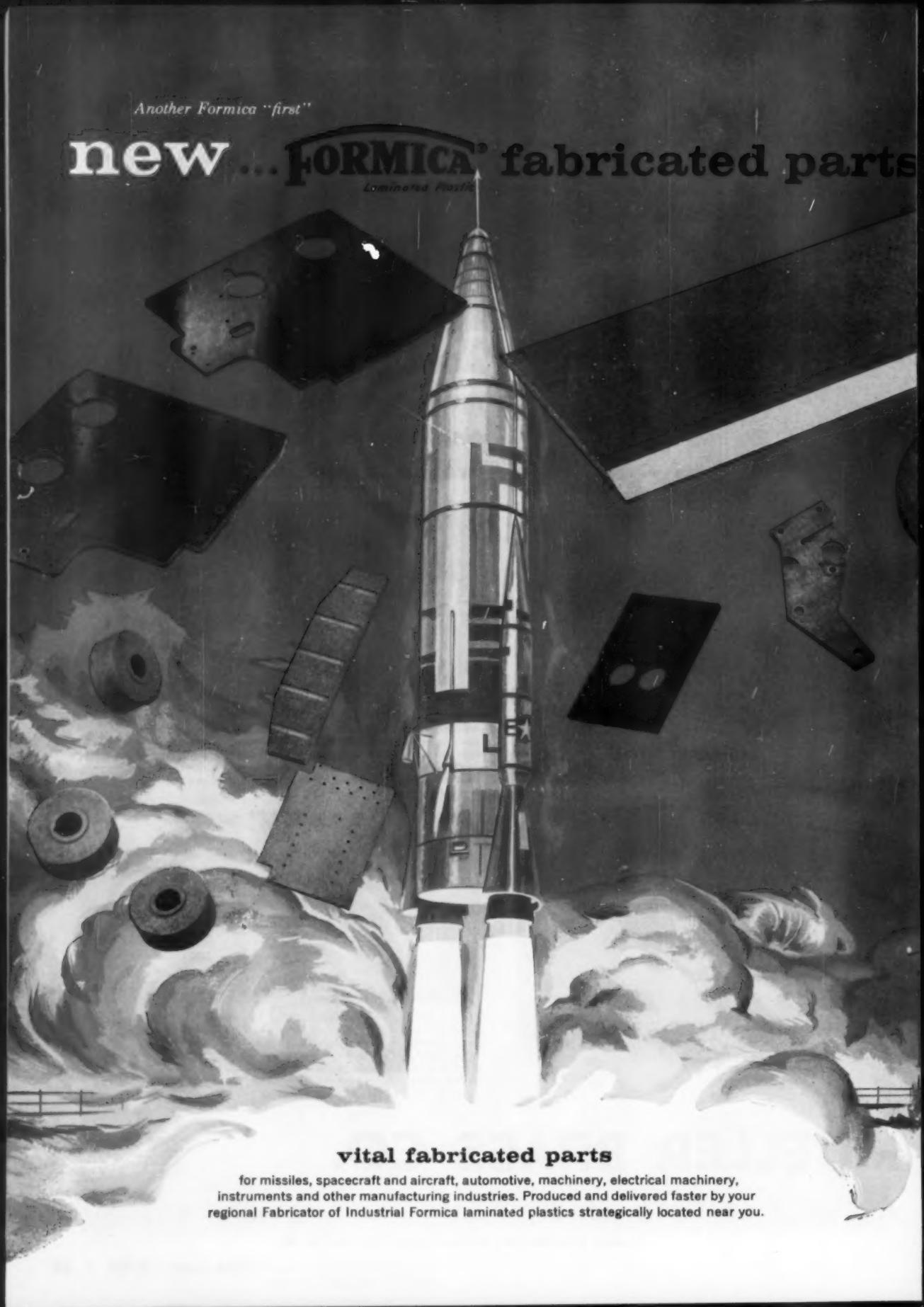
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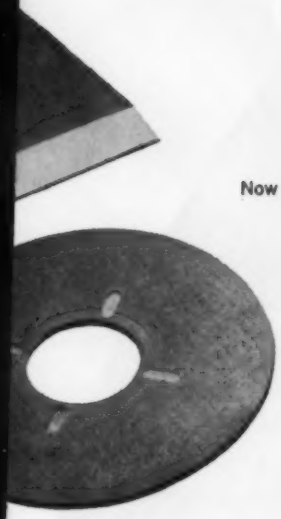

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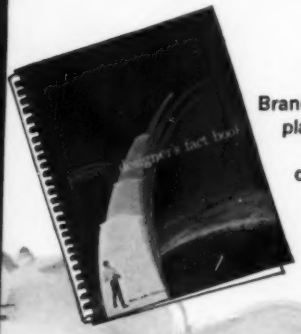

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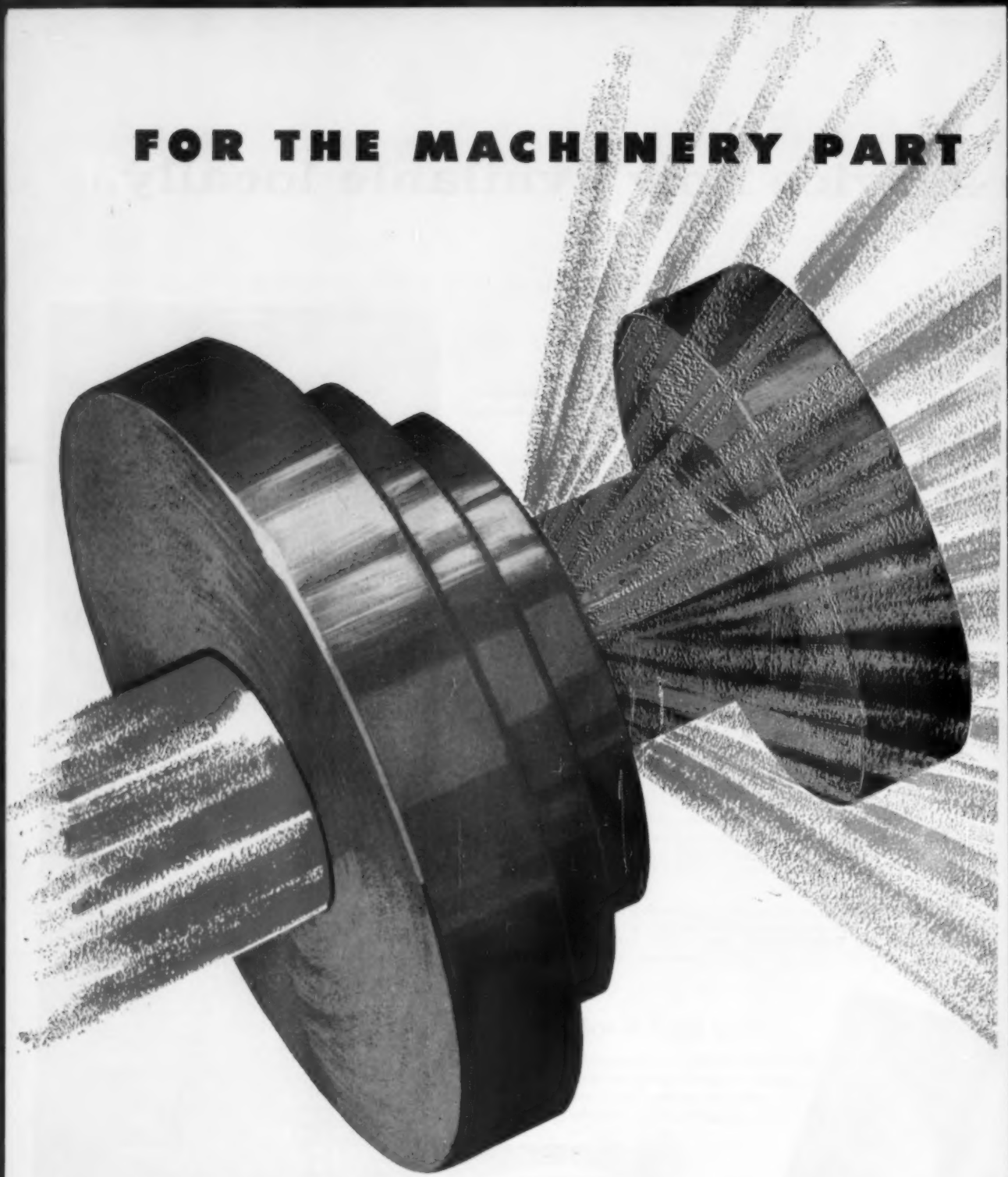
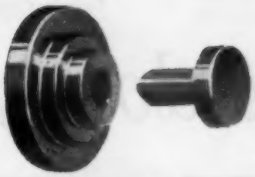
FOR THE MACHINERY PART



THAT TAKES THE BEATING



Liquids forced at high pressure through restricting valves—of HAYNES STELLITE alloy! That's the modern way by which hundreds of products are homogenized today, to make better dairy, chemical, food, and textile products, to name a few.

HAYNES alloys have been a standard material for homogenizer valves for 25 years. Valves that remain free from roughness, porosity, sharp corners, pits. Valves that retain their dimensions where pressures may reach 15,000 psi, and liquid velocities exceed 30,000 ft. per minute. Valves that keep products clean and free from contamination and give long service despite corrosive and abrasive conditions.

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Our engineers will help you pick the right HAYNES alloy to resist practically any condition of wear, heat, or corrosion. For more information write for descriptive literature.

HAYNES Alloys *will do the job!*

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HAYNES STELLITE COMPANY

Division of
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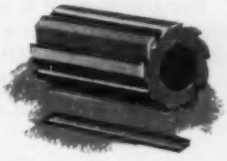
TYPICAL "HAYNES" ALLOY MACHINERY PARTS

Chuck inserts of HAYNES STELLITE alloy last up to 50 days—2 shifts daily—holding heavy pieces during a cut-off operation.

Seam rollers on milk-can machines turn out 2 to 3 times as many cans now that the rollers are made of HAYNES STELLITE alloy.



Cutters and bed knives made of HAYNES STELLITE alloy stay clean and sharp for years while pelletizing extruded polystyrene.

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To prevent moisture and dust from entering automobile light sockets, a **chem-o-sol** was specially formulated for an economical high-speed dipping process (no costly molds required). It provides a tough, flexible coating. *(Watts Electric & Mfg. Co.)*

To resist corrosion, drums, tanks, and other large irregularly-shaped objects are sprayed with a structurally strong **chem-o-sol.** Cost savings of up to 35% result, and films of from 5 to 100 mils are possible.

To provide an essential coating for glass yarn used in strong, weather-resistant screening, a **chem-o-sol** with the correct flow properties was produced for economical application by high-speed die-wiping. *(Owens-Corning Fiberglas Corp.)*

To produce a tight seal that is permanently flexible and durable, a specially formulated **chem-o-sol** was tailored for clay pipe joints. A "flowed-in" gasket, it's applied by an in-plant molding process.

What they're doing with

may suggest an easier way to

ECONOMICAL TO APPLY
chem-o-sol ALSO HELPS CUT PRODUCTION COSTS

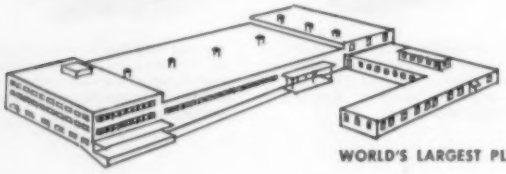
These are just a few of the applications already developed for Chem-o-sol. So versatile is this polyvinyl dispersion . . . so advanced the research, so vast the formulating experience and production capacity of Chemical Products Corporation that Chem-o-sol's product improvement possibilities are virtually *unlimited.*

For Chem-o-sol is more than a coating or molding *compound.* It is a new production tool! Formulated as a liquid without volatile components, it is converted to a strong, resilient solid simply by heating to about 350°F., *without pressure.*

Since each Chem-o-sol formulation is "tailor-made" to best suit the specific requirements of the end use, the formulator's touch is indispensable for translating ideas into reality.

To its practical experience, unsurpassed in point of time or scope, Chemical Products Corporation adds the world's largest and most modern facilities for the development and production of polyvinyl dispersions, including a completely equipped research laboratory to serve you.

IS THERE AN IDEA HERE for improving your own product? Then tell us about the proposed end use of Chem-o-sol.



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To impart a slip-proof, safety grip and increase wearability of cotton work gloves, palms and fingers are strategically dotted with chem-o-sol specially formulated to permit printing on fabrics at high speeds. *(Wells Lamont Corp.)*

To deaden noise, protect dishes from chipping, and resist grease and detergents, the familiar drainer is dipped in a special **chem-o-sol.** Wire constructions and metal and glass objects are coated easily and economically because only one dipping operation is necessary. Thickness to 60 mils is possible, in wide range of finishes.

To seal the new dry type automotive air cleaner into the car silencer and act as a structural member of the pleated paper element, a **chem-o-sol** was compounded for high-speed molding. Pre-cut gaskets and metal stampings were eliminated. *(Fram Corporation.)*

To improve heat resistance and physical and electrical properties of coatings for flexible sleeving (spaghetti tubing) used in electrical components, a **chem-o-sol** was tailor-made for heat resistance of more than 2000 hours at 225°F.

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improve your product

TECHNICAL FACTS ABOUT chem-o-sols

Chem-o-sols possess all the outstanding physical and chemical properties associated with polyvinyl chloride resins. Listed below are some of the properties available in almost any combination.

COLOR CHOICE — unlimited

TENSILE STRENGTH — as required from 1000 psi. to 2700 psi.

PERCENT ELONGATION — 350 to 600

HARDNESS (shore A2) — as required from 10 to 100
(shore D) — up to 65

FLEXIBILITY — to temperatures as low as **—65°F**

CHEMICAL RESISTANCE — outstanding to most acids, alkalies, detergents, oils and solvents

HEAT RESISTANCE — available to 225°F for as long as 2000 hours and to 450°F for over two hours

DIELECTRIC STRENGTH — minimum of 400 volts per mil when fused in sections 3 mils thick and over

SOLIDS CONTENT — 100%. Chem-o-sols can be molded in very thick sections

VISCOSITY — as required for dipping, die wiping, molding, casting, spraying, or spreader coating

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Dept. M-2, King Philip Road
East Providence 14, R. I.

Please send me a free copy of your **chem-o-sol** Brochure.

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Title .....

Company .....

Address .....

City ..... Zone ..... State .....

Proposed end use .....

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Application method .....

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Amchem Alodine...

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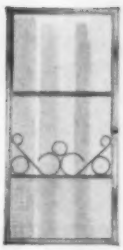

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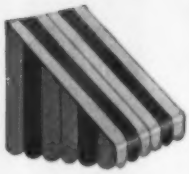

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The Amchem Alodine process forms an amorphous coating which becomes an integral part of the metal, enhances the natural corrosion resistance of the aluminum and provides an excellent bond for paint.

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Beyond product, Amchem provides the metalworking industry a complete service—processes, technical and engineering assistance, installation and instruction service—for corrosion protection, paint bonding, or other metalworking problems.

Write for complete information contained in Bulletin 1424A describing the uses of Amchem Alodine, as well as other literature pertinent to Amchem chemical conversion processes for the metalworking industry.

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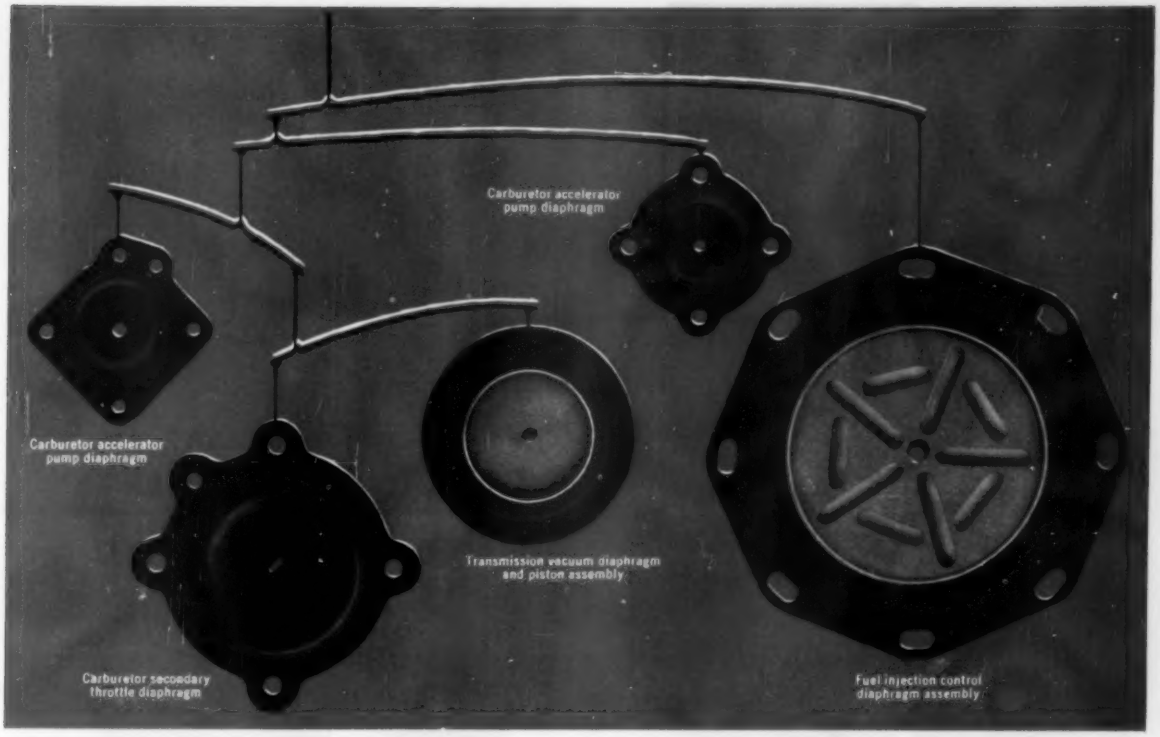
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Transmission vacuum diaphragm and piston assembly
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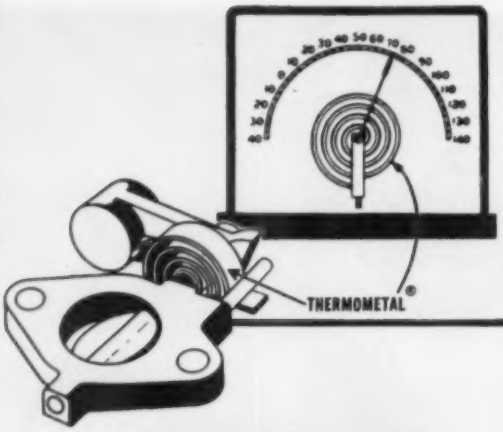

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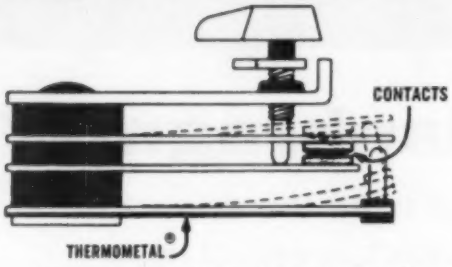

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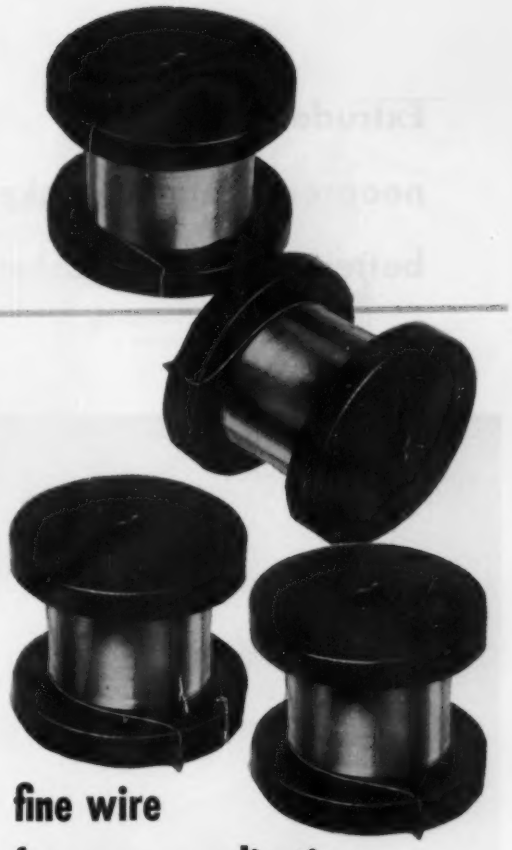

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Extruded closed cell neoprene sponge makes better appliance gaskets

Gasketing material of closed cell neoprene sponge is helping solve some of the major problems in appliance sealing. Made of a non-absorbent sponge body and thin, tough neoprene outer skin, this sealing material performs well under the most severe conditions. Manufacturers' acceptance tests show that it can take hot water, detergents, cooking oils and food chemicals without harm. This gasketing material also has excellent resistance to abrasion, ozone and natural aging. If you design or manufacture an appliance or assembly involving a compressible seal, you will want more details. Write to E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Department (MM-2), Wilmington 98, Delaware.

Above—Acceptance tests on neoprene sponge were run for 100 hours in water at 212°F., food fats and detergents at 180°F. Results showed less than 10% swell, low water absorption, no damage to sealing properties.

Upper left—Tough neoprene skin on extruded gasket resists abrasion, ozone, natural aging—won't chip, crack or peel. Closed cell neoprene sponge retains its compressibility and sealing pressure.

Left—Neoprene sponge gasket can be bent around sharp radii without wrinkling. Sharp corners can be cut and cemented; closed cell sponge structure is non-absorbent.

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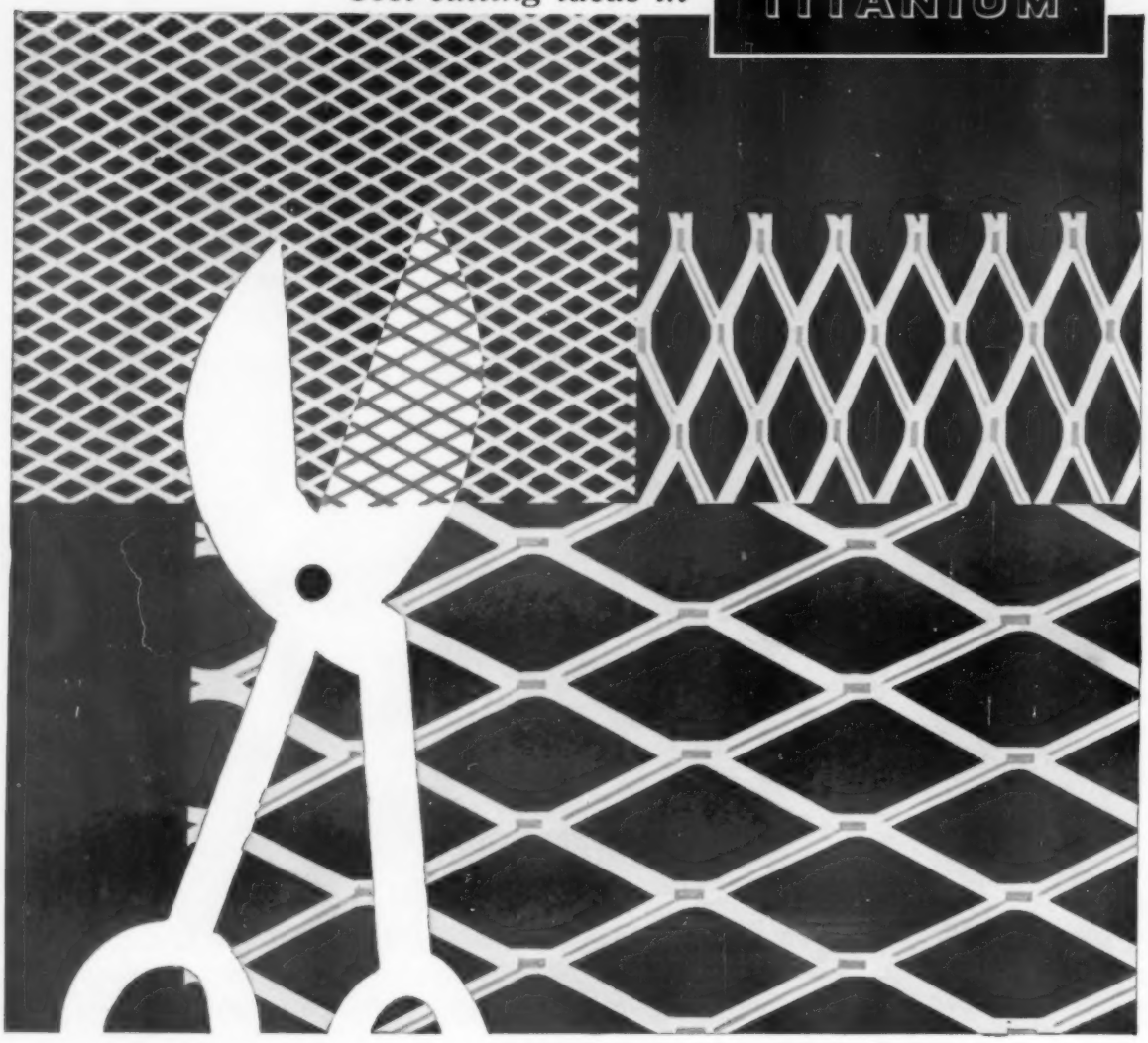

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Suppliers' Literature No.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108
109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135
136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162
163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189
190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216
217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243
244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270
271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297
298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324
325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	

Information on Advertisement No.

361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387
388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414
415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441
442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468
469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495
496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522
523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543	544	545	546	547	548	549
550	551	552	553	554	555	556	557	558	559	560	561	562	563	564	565	566	567	568	569	570	571	572	573	574	575	576
577	578	579	580	581	582	583	584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600	601	602	603
604	605	606	607	608	609	610	611	612	613	614	615	616	617	618	619	620	621	622	623	624	625	626	627	628	629	630
631	632	633	634	635	636	637	638	639	640	641	642	643	644	645	646	647	648	649	650							

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PAGE NOS.

Acetate 60-61, 214, 217
ABS plastics 133
Acrylics 53, 165, 174, 214, 217
Adhesives 59
Aluminum and its alloys 14, 122, 127, 141, 147, 179, 213, 217, 221

Balls 198
Bearing materials 64-65, 131, 132, 138, 148, 158, 192
Bimetals 30, 162
Brazing alloys 74
Butyrate 60-61, 165, 214

Carbides 24-25, 127, 135, 173, 176, 198
Carbon, graphite 64-65, 148, 158, 216
Castings, centrifugal 184
Castings, die 8, 154, 156, 217
Castings, permanent mold.....14, 58, 70-71, 132, 142, 171, 184, 203, 204, 211
Castings, precision ...16, 68, 207, 218
Castings, sand 14, 24-25, 58, 70-71, 132, 142, 171, 184, 203, 204, 211
Cellular materials 6, 32, 77, 221
Ceramics 77, 181
Clad metals 76
Cleaners, metal 145, 207
Coating, electrostatic spray 168
Coatings, ceramic 63
Coatings, chemical conversion.... 28, 69, 207
Coatings, diffusion 136
Coatings, metallic 31, 52, 54, 63, 75, 208
Coatings, porcelain 56-57
Coatings, vinyl 5, 26-27, 146, 185
Cobalt and its alloys 24-25
Columbium 150
Copper and its alloys .....9, 14, 15, 44, 49, 134, 141, 147, 211, inside front cover

PAGE NOS.

Diallyl phthalate 218
Diaphragms 29
Dies, custom 199
Drawn shapes 182, 202

Epoxies 13, 159, 183
Extrusions, metallic 20-21, 221
Extrusions, nonmetallic 140, 165, 194, 214

Fasteners, mechanical 191, 210, 214, 217
Felts, wool 72, 217
Fluorocarbon plastics ..134, 178, 186
Forgings 24-25, 43, 213

Gaskets 32, 165, 205, 207, 221
Glass 77, 164, 166

Heating, heat treating 199
High temperature alloys ...24-25, 45, 62, 68, 151, 184, 193
Honeycomb materials 127

Inserts, threaded 210
Iron, alloy 24-25
Iron, ductile 142
Iron, malleable 70-71

Laminates, plastics 22-23, 127, 172, 194, 205, 217
Low melting alloys 211

Magnesium 200, 213
Metal forming machines 129
Metal powder parts 131, 132, 158
Metal powder presses 42
Metal powders 9, 180
Metals, expanded 34
Metals, high density 188
Moldings, plastics 134, 138, 200, 206, 209
Moldings, rubber ..140, 203, 207, 208
Molybdenum 150

Nickel and its alloys 2, 14, 52, 76, 184, 201

Oxides 135, 173

Papers 203, 212
Phenolics 51
Plastics (see specific types)
Plastics, metallized 146
Plastics, reinforced 18-19, 127, 163, 206

PAGE NOS.

Platinum and platinum group alloys 76
Polyamides 165, 192, 194, 217
Polyesters 51, 139, 143, 146, 163
Polyethylenes 60-61, 165, 214, 217
Polystyrenes 46-47, 217
Polyvinyl chloride 5, 26-27, 190
Precoated & preplated metals 55, 152

Quartz, fused 30

Refractory materials 135
Roll formed shapes 179
Rubber, synthetic .....6, 32, 140, 177, 221, inside back cover

Sealants 212
Sealing alloys, glass-metal 76
Seals 64-65, 207
Shims 130
Silicones 119-120
Spinnings 129
Stampings, punchings ..202, 211, 221
Steel, carbon 17, 50, 67, 161, 211
Steel, heat and corrosion resistant 45, 55, 67, 127, 171, 193, 201, 202
Steel, low alloy.....50, 187
Steel, specialty 67, 78
Steel, tool and die 169
Strip, precision rolled 17
Swaged parts, metal 160

Tantalum 150
Tape, contact 196
Testing Equipment 73, 144
Tin and its alloys 128
Titanium 34, 66, 173, 213
Tubing & pipe, metallic ....45, 48, 76, 78, 141, 147, 178, 189, 210, 216, 219, back cover
Tubing & pipe, nonmetallic .134, 138, 149, 165, 178, 186, 190, 192, 194, 205, 214, 217
Tungsten and its alloys..... 150

Urethane plastics foams 143, 215

Vinyls 165, 190
Vulcanized fibre 194, 205

Weldments 202
Wire 31, 62, 151, 153, 211
Wire forms 202
Wood 122

Zinc and its alloys 8, 217

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Suppliers' Literature

Books, p 214

Reports, p 218

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High Temperature Metals. Universal-Cyclops Steel Corp., 50 pp, illus. Specifications, forgeability, heat treatment, chemical analysis, weldability, mechanical properties and corrosion resistance of high temperature alloys. 115

Cold Formed Parts. Van Huffel Tube Corp., 48 pp, illus. Information on cold formed metal parts. 116

Investment Casting Alloys. Wal-Met Alloys Co., 4 pp, illus. Information on tool and stainless steel certified alloys for investment castings. 117

Stainless Steel. Wallingford Steel Co., 52 pp. Chemical composition, comparative proper-

TECHNICAL LITERATURE

ties, corrosion resistance, tolerances and fabrication of stainless steel. 118

Stainless Steel. Washington Steel Corp., 32 pp. illus. Physical properties, composition, fabrication, corrosion and heat resistance, and cleanability of special purpose stainless steel sheet and strip. 119

Stainless Steel Castings. Waukesha Foundry Co., Castings Div., 8 pp, illus., No. SS. Physical properties and uses of martensitic, ferritic and austenitic stainless steel castings. 120

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Gray Iron Castings. Zenith Foundry Co., 20 pp. illus. Shows how quality control is used in the production of gray and alloy iron castings. 123

Nonferrous Metals • Parts • Forms

Aluminum Parts. Aluminum Co. of America, 20 pp, illus. Use of aluminum screw machine stock in the manufacture of cameras, instruments, flaming reels, outboard motors and dictating machines. 127

Aluminum Castings. Aluminum Industries Inc., 4 pp. illus., No. 20A. Company facilities for producing aluminum castings. 128

Copper Foil. American Brass Co., Ansonia Div., 8 pp, illus., No. D-8. Lists grades available, weights, thickness and tolerances of electrolytic copper foil. 129

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Beryllium Metal. Brush Beryllium Co., 24 pp, illus. Information on strength, corrosion resistence, machinability, and electrical and optical properties of beryllium metal. 139

Sintered Bronze. Bunting Brass & Bronze Co., 12 pp. illus., No. P-56. Information on stock bearings, washers and bars made of sintered bronze. 140

Vacuum Melted Alloys. Cannon-Muskegon Corp., 7 pp, illus., No. 71. Economics of investment cast vacuum alloys. Prices of air, argon and vacuum investment castings. 141

Magnetic, Electrical Alloys. Carpenter Steel Co., 65 pp. illus. Chemical composition, magnetic properties, machinability and mechanical properties of iron-nickel alloys. 142

Titanium Tubing. Carpenter Steel Co., Alloy Tube Div., 8 pp, illus. Physical and mechanical properties, fabrication characteristics, and corrosion resistance of titanium tubing and pipe. 143

Investment Castings. Casting Engineers, Inc., 8 pp, illus., No. 120. Use of polystyrene plastics patterns for close tolerance investment castings. 144

Die Pressed Brass Forgings. Chase Brass & Copper Co., 4 pp. illus. Three-dimensional photographs compare die pressed brass forgings and brass sand castings. 145

Copper-Base Alloys. Copper & Brass Research Assn., 25 pp, illus. Properties, machinability, uses and specifications for copper, zinc brasses, tin brasses, nickel silvers, phosphor bronzes, and aluminum bronzes and brasses. 146

Magnesium Tooling. Dow Chemical Co., Magnesium Dept., 55 pp, illus. Design information, properties, finishing, machining, grinding, polishing, joining and uses of magnesium for lightweight tooling. 147

Sealing Alloys. Wilbur B. Driver Co., 4 pp. Mechanical and physical properties of nickel-iron and nickel-cobalt-manganese-iron alloys for sealing glass to metal. 148

Resistance Alloys. Driver-Harris Co., 8 pp, illus. Four bulletins describe enameled wire for resistors; an alloy with a specific resistance of 1000 ohms per cmf; a heating element alloy; and a thermocouple for high temperatures. 149

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Aluminum Castings. Exalco Mfg. Co., 4 pp. illus. Information on standard and custom-made aluminum permanent mold castings. 151

Tantalum Sheet, Foil. Fansteel Metallurgical Corp., Metals & Fabrication Div., 6 pp, No. 2.602-1. Ordering data, prices, sizes and tolerances for tantalum sheet and foil. 152

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Aluminum Extrusions. General Extrusions, Inc., 6 pp, illus. Properties, uses, surface finishes, lengths and tolerances of aluminum extrusions. 154

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Precision Made Parts. Hamilton Watch Co., 16 pp. illus. Special alloy casting, rolling, drawing to fine specifications. 156

Indium Alloys. Indium Corp. of America, 93 pp. graphs. Constitution of indium alloy systems. 157

Beryllium Copper Parts. Instrument Specialties Co., Inc., 20 pp, illus., No. 10. Design information, properties and uses of beryllium copper springs and screw machine products. 158

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Impact Extrusions. Mueller Brass Co. Mechanical properties and dimensional tolerances of round, rectangular and square impact extrusions. 163

Zirconium Metal. Zirconium Metals Corp. of America, Div. of National Lead Co., 68 pp. Physical and mechanical properties, uses and weldability of zirconium metal. 164

Nonferrous Castings. Ohio Precision Castings, Inc., 16 pp, illus. Information on castings made from brass, bronze, aluminum and beryllium copper. 165

Copper Tubing. Penn Brass & Copper Co., 6 pp, illus. Safe internal working pressures for seamless copper tubing. 166

Phosphor Bronze. H. K. Porter Co., Inc., Riverside-Alloy Metal Div., 4 pp. illus., No. T-4. Outlines advantages, applications and features of a fine grain phosphor bronze. 167

Aluminum Extrusions. Precision Extrusions, Inc., 12 pp, illus., No. 5702. Properties and uses of extruded aluminum alloys. 168

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Roll Formed Shapes. Roll Formed Products Co., 26 pp, illus. Information on roll formed shapes produced from both ferrous and nonferrous metals. 171

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Extruded Brass Wire. Scovill Mfg. Co., 4 pp. illus. Characteristics, temper, coil sizes, weight and composition of extruded brass wire. 173

Nonferrous Alloys. Seymour Mfg. Co., 40 pp. illus. Properties, and cleaning and annealing information on nickel silver and phosphor bronze. 174

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Etching Metal Parts. Superior Tube Co., Photo-Forming Dept., 10 pp. illus., No. 90. Describes photo-forming of metal parts. Two processes—chemical etching and electrolytic etching—are described. 176

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Cold Rolled Strip. Techalloy Co., Inc., 4 pp. illus. Uses, properties and price information for cold rolled monel, nickel, Inconel, Inconel X, stainless steel, beryllium copper and phosphor bronze strip. 178

Tantalum. Wah Chang Corp., 2 pp. Fabrication data, uses, and physical, mechanical and chemical properties of tantalum. 179

Aluminum Extrusions. R. D. Werner Co., Inc., 4 pp. illus. Sizes and uses of aluminum extruded and roll formed shapes. 180

Metals for Aircraft. Westinghouse Electric Corp., Blairsville Metals Plant, Materials Mfg. Dept., 8 pp. illus. Research in wrought alloys and molded metal products for high speed aircraft and missiles. 181

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Plastics & Rubber • Parts • Forms

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mechanical and electrical properties of urea formaldehyde and methyl styrene molding compounds. **188**

Polyurethane Foam. American Latex Products Corp. Uses, formulations and physical properties for rigid, semi-rigid and flexible polyurethane foams. **189**

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TECHNICAL LITERATURE

Silicone Rubber. Colonial Rubber Co., Div. of U. S. Stoneware Co., 3 pp. Physical properties, sizes and uses of 50, 70 and 80 Durometer silicone rubber sheets. **257**

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Other Nonmetallics • Parts • Forms

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Joining & Fastening

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Methods & Equipment • Testing

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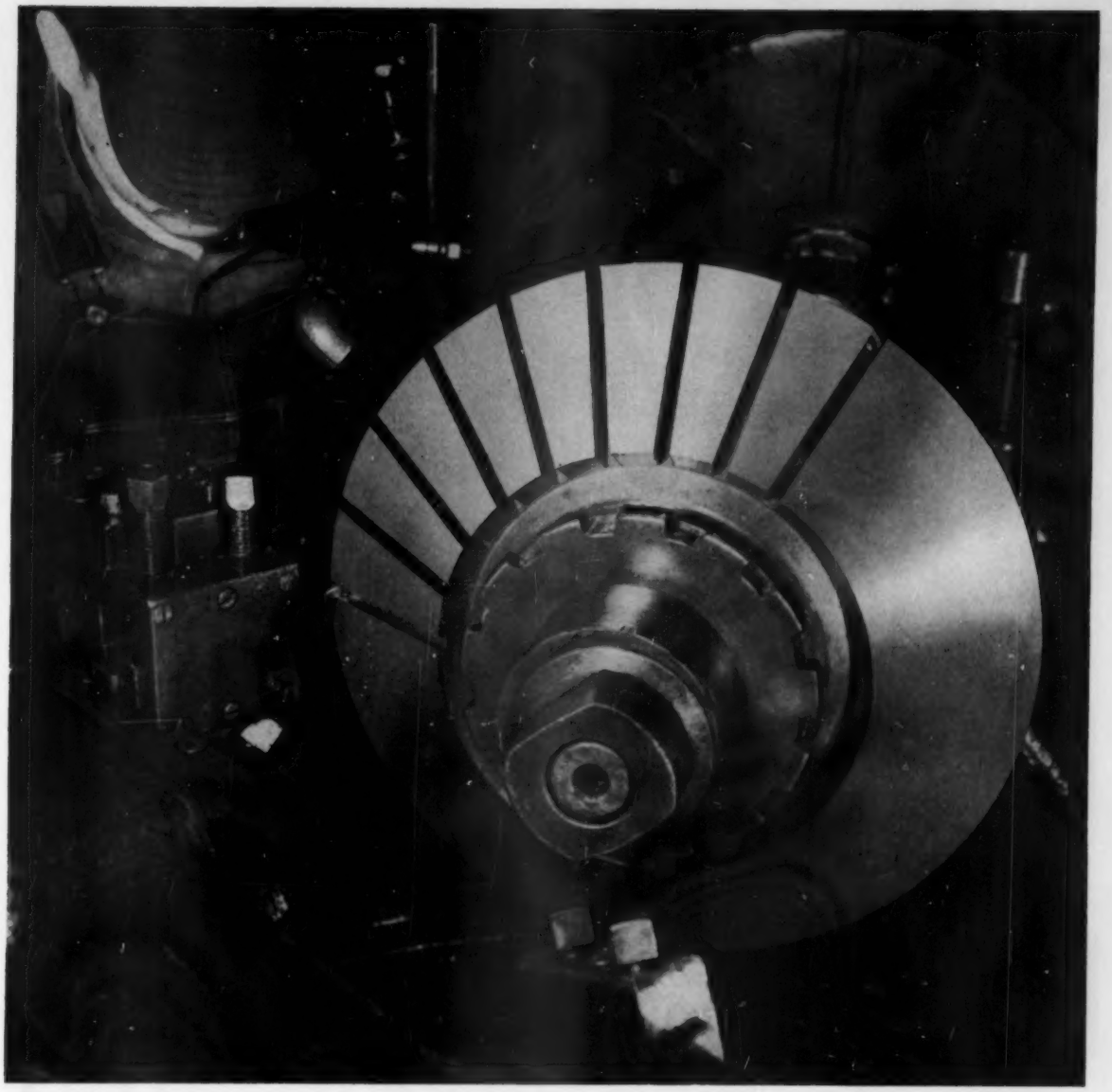

You can machine them with confidence

When gears are made from Bethlehem forged-and-rolled blanks, machinists often report faster progress and a better finished job. The blanks are so sound, and have such excellent grain flow, that even the "touchiest" machining can be done with confidence.

Asked what he likes best about these blanks, a veteran production man answered, "They're easy to machine. When you're cutting teeth, you need metal that's clean and solid all the way through."

But there's another important advantage—*strength*. Bethlehem's forging-and-rolling process, unduplicated anywhere, assures the high strength always needed for heavy-duty products. Because of this, the blanks are unsurpassed for gears, crane and sheave wheels, turbine rotors, flywheels, pipe flanges, and other circular parts. Available heat-treated or untreated, they can be furnished in sizes from 10 to 46 in. OD. Write for Booklet 216.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

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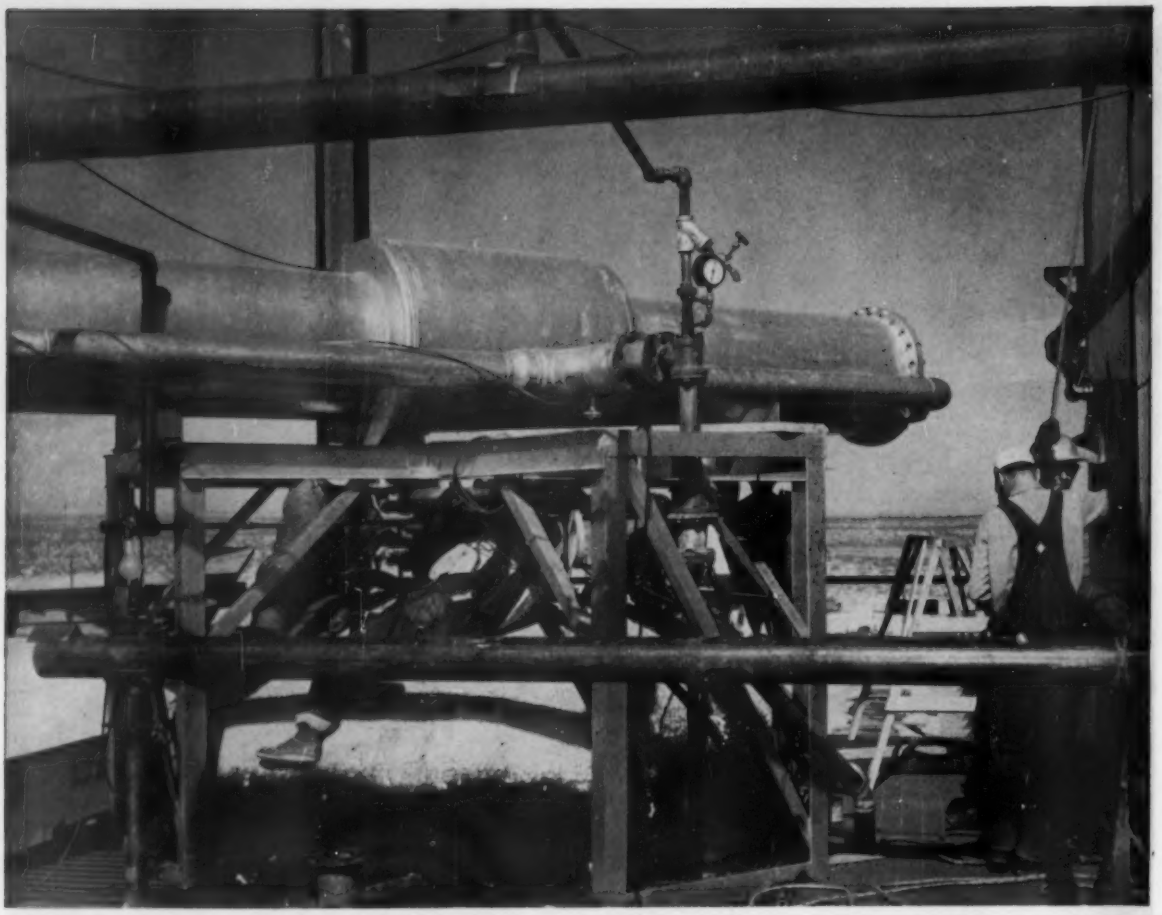

Erecting a crystallizer at a potash refinery in Carlsbad, N. M. operated by the U. S. Potash Co., a division of U. S. Borax & Chemical Corp. This is one of seven crystallizers that were shop- and field-fabricated then field-assembled by welding. They were not stress-relieved or heat-treated. There has been no stress-corrosion cracking in the nine months these units have been in service.

NEW Ampco Metal Grade 8 stops stress-corrosion cracking!

Important changes have been made in Ampco Metal Grade 8! It's *entirely new*—and completely obsoletes old ideas about fabricating copper-base alloy equipment to handle steam and corrosive media at elevated temperatures.

Now, with new, patented Ampco Metal Grade 8, you can . . .

1. Field-fabricate *without stress-relieving!*
2. Make field repairs, changes, and alterations *without heat treatments!*
3. Readily weld with any electric welding process! A. No pre-heat. B. No post-heat. C. No hot-short cracking!

At one major oil refinery, field-assembled piping of Ampco Metal Grade 8 has handled hot sulphuric-acid sludge for a year and a half without stress-corrosion-cracking. Driers in a paper mill have handled 350° F steam at 125-lbs. pressure for more than a year without stress-corrosion cracking.

Let us prove it to you. Talk to your Ampco field engineer. Or write for details. *Ampco Metal, Inc., Dept. MDE-11B, Milwaukee 46, Wis. (West Coast Plant: Burbank, Calif — Southwest Plant: Garland [Dallas County], Texas).* TS-1

AMPCO

AMPCO

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Tubexperience in action

"They use this Super Alloy tubing in missiles, rockets and jets

—so you know it can lick your heat and corrosion problems!"

*"It's made by Superior Tube in your choice of 16 different materials. Believe me, this tubing can take the severest conditions of heat, corrosion and oxidation. Has very high fatigue and creep strength even at temperatures over 1000°F."

If you have a temperature and corrosion problem that causes failure no matter what type of tubing you have tried, get your Superior distributor to order Super Alloy tubing for you—it is the tubing for virtually every critical application of this nature.

Super Alloy tubing offers the important properties mentioned above, plus the dependability and longer service life built into it by Superior skills and experience. We will put your tubing through many special examinations if you want us to—eddy current and ultrasonic, hydrostatic, and hot tensile tests, stress rupture tests, qualitative and quantitative analysis, and many others—for your complete assurance in its ability to perform as required.

Our continuing test program on Super Alloy tubing has amassed much useful information on mechanical properties. You will want to make a study of them and their potential for use in your applications. They are covered in our Bulletin 70. Send for copies. Superior Tube Company, 2006 Germantown Ave., Norristown, Pa.

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The big name in small tubing

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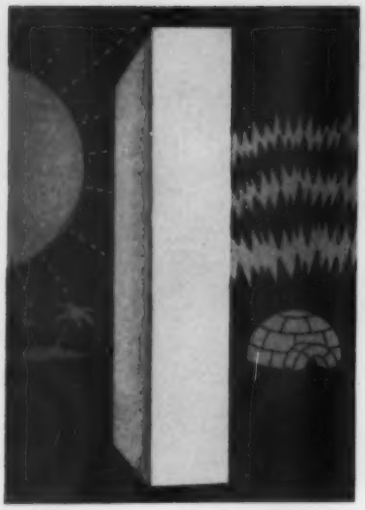
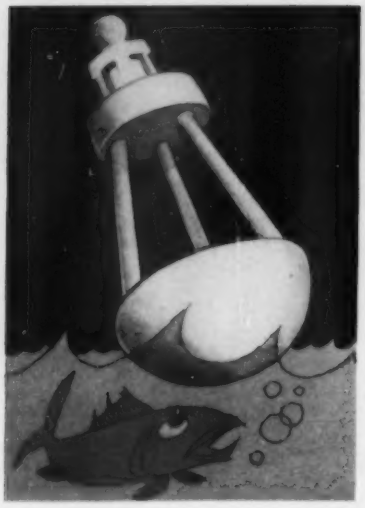
FIVE REASONS WHY
IS THE BEST ANSWER



DYLITE
IS AN INSULATOR

The Thermal Conductivity (K Factor) of DYLITE is 0.242 at a 75°F. mean temperature at 2 lb./cu. ft. density. DYLITE is highly resistant to the passage of heat and is unaffected by moisture condensate. DYLITE is easily molded to fit the contours of component parts of refrigerators, air conditioners and freezer cabinets.

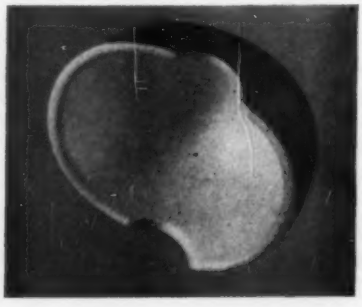


DYLITE
IS WATERPROOF

At 2 lb./cu. ft. density, DYLITE's rate of Water Vapor Transmission is 1 18 perms., and its rate of Water Absorption is 0.54 lbs./cu. ft. after 48 hrs. immersion. DYLITE is ideal for boats, rafts, buoys and other types of buoyant marine equipment. DYLITE remains in the water indefinitely without becoming waterlogged, and it is mildew-proof.

DYLITE
IS SHOCK-RESISTANT

DYLITE possesses an Energy Absorption ratio (Maximum Load) of 56.74 in. lbs./cu. in. at a density of 2 lb./cu. ft. For example, police safety helmets with shock-absorbent DYLITE liners are now used extensively—a result of performance tests in which DYLITE was proved superior to other materials for this job.



Typical Properties of DYLITE—Density 2 Lb./Cu. Ft.

- Compressive Strength—30 Psi
- Tensile Strength—55 Psi
- Water Vapor Transmission—1.18 Perms.
- Water Absorption—0.54 Lbs./Cu. Ft. After 48 Hrs. Immersion
- Thermal Conductivity (K Factor)—0.242 at a 75°F. Mean Temperature
- Energy Absorption (Maximum Load)—56.74 In. Lbs./Cu. In.

DYLITE is a registered trademark of Koppers Company, Inc.

DYLITE

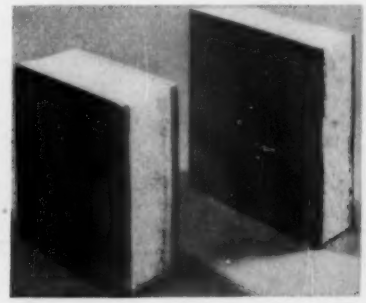
TO YOUR DESIGN PROBLEMS

DYLITE IS LIGHTWEIGHT

DYLITE is lighter than cork—it can be molded in densities of 1 to 10 lb./cu. ft. The advantages of light weight are obvious. In packaging, DYLITE helps reduce shipping costs and makes handling easier. In the construction field, where DYLITE is used as an insulator, its light weight means fast and easy installation.

DYLITE IS STRONG

DYLITE has a Compressive Strength of 30 psi and a Tensile Strength of 55 psi at a 2 lb./cu. ft. density. DYLITE can be used to great advantage in a wide variety of industrial design problems. For instance, sandwich structures that employ DYLITE as the core material offer high strength without sacrificing light weight.



KOPPERS

Offices in Principal Cities: In Canada: Dominion Anilines and Chemicals Ltd., Toronto, Ontario

KOPPERS PLASTICS

DYLITE

Koppers Company, Inc.
Plastics Division
Dept. MDE-29
Pittsburgh 19, Pennsylvania

☐ Please send me more information on DYLITE expandable polystyrene.

☐ Please have Koppers representative call.

☐ I'd like more information on DYLITE concerning possible application in _____

Name _____

Firm _____

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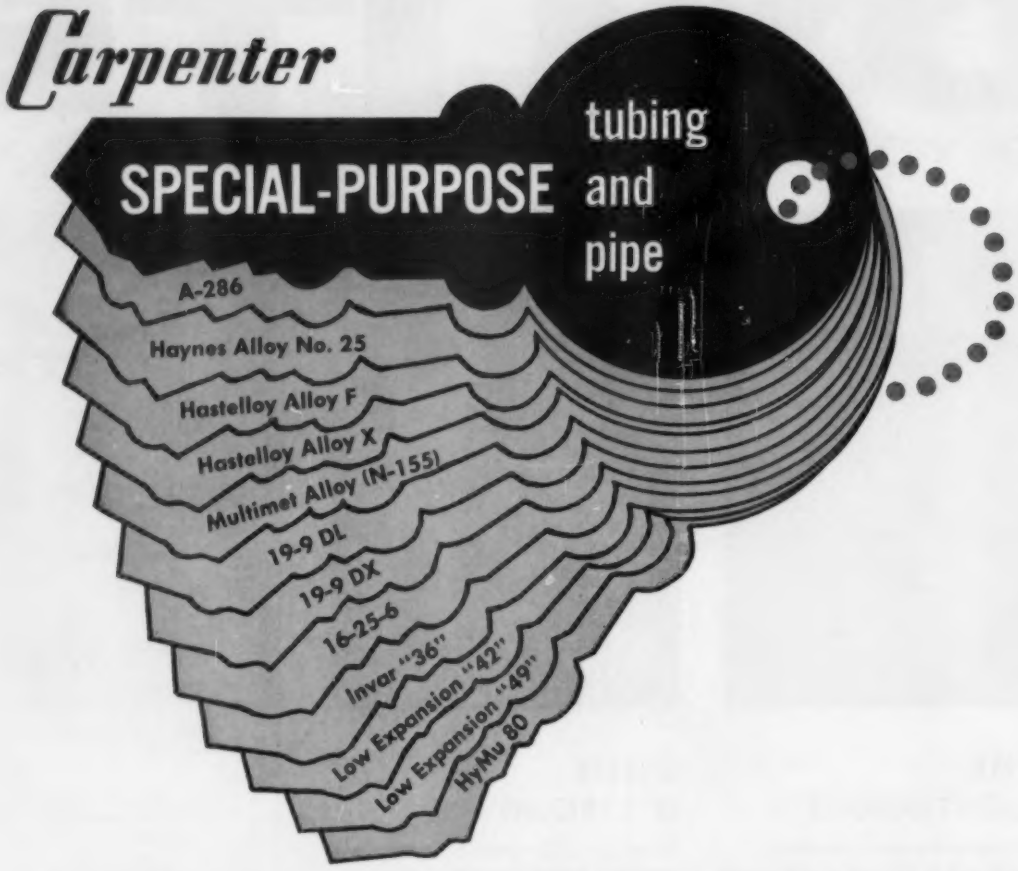

12 master keys to many NEW needs

● As fast as new developments in products and equipment create new needs in tubing and pipe for corrosion and heat control, Carpenter is ready with the answers. Whatever it takes, Carpenter makes . . . to meet the challenge of technological progress.

Listed above are 12 Special-Purpose types of Carpenter tubing and pipe that answer today's needs for high-temperature, low-expansion, high-permeability and corrosion-resistant applications. These super-stainless and high alloy grades meet a broad range of tubing and pipe requirements for vital parts of jet aircraft, missiles, rockets, nuclear energy equipment, instruments, electronic devices, process equipment and other advanced developments. Their properties, recommended uses and other technical data are contained in a new bulletin—T.D. 125.

Write for a copy on your company letterhead. Put your special-purpose requirements for tubing and pipe in Carpenter's capable hands by contacting our nearest office. The Carpenter Steel Company, Alloy Tube Division, Union, N. J.

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If your plans demand the best bronze, **specify Federated Engineered Bronze *by name!***

As you know, the truly engineered bronzes—silicon, aluminum, and manganese—offer combinations of properties not available in other metals. Federated's extensive facilities deliver the precise qualities wanted. Continual controls during alloying under the direction of metallurgical specialists, assure performance that always meets, often exceeds, specifications. Call one of Federated's 21 sales offices for information about Federated Engineered Bronzes, conveniently produced in Los Angeles, Whiting, (Ind.), Perth Amboy, (N. J.), San Francisco, Houston. Federated Metals Division, 120 Broadway, New York 5. In Canada: Federated Metals Canada, Ltd., Toronto and Montreal.

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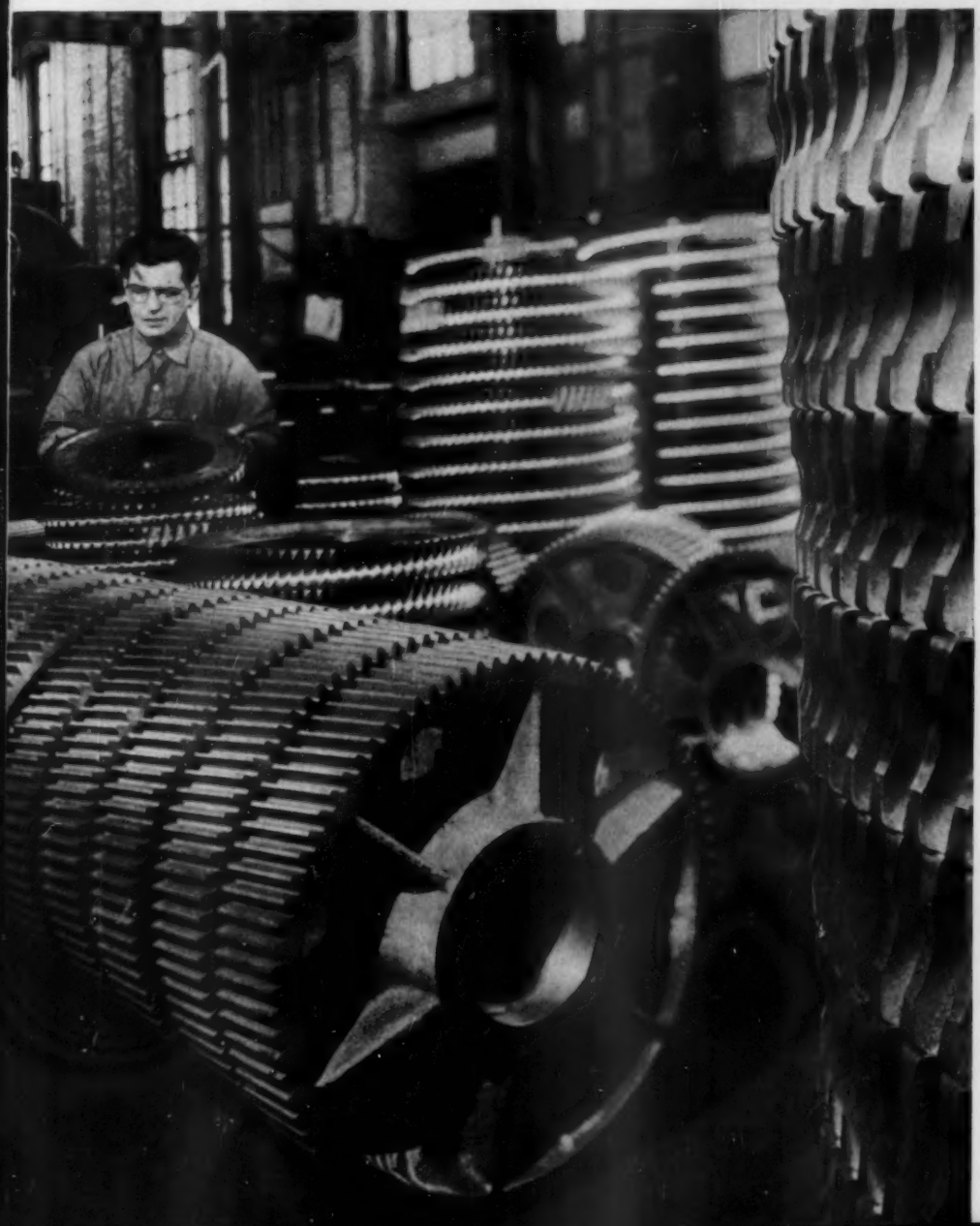

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AMERICAN SMELTING AND REFINING COMPANY

CARBON AND ALLOY STEEL INVENTORIES...

They can and will—if you let *Frasse* stocks be your inventory! Your cost for steel ready for use will be less. You'll save the cost of labor, handling, processing and obsolescence...free plant space and idle capital for profitable use. You incur no expense until material is needed...then only the cost of steel—*not* the purchase price PLUS the *high cost of possession.*

With Frasse stocks as your inventory, you can pick from 20 different grades—any one of 2001 sizes. For, Frasse carries a complete range of carbon bars and shafting as well as commercial and aircraft quality alloys. There's always a size and grade for any application...*immediately available.*

Weigh the advantages of this modern solution to steel inventory problems. You get broad selection, fast deliveries—and the help of specialists that offer a wealth of technical information and problem-solving techniques. Place future orders for the carbon and alloy bars you need with Frasse—*your* Steel Service Center. You'll find it convenient...and far more economical than maintaining your own inventory.

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COMPLETE

CARBON AND ALLOY STEEL SERVICE

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C1045	C1212	E4130
B1112	C1213	4140
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4140 H.T. • 4142 H.T.

Precision Shafting • Special Finish
Turned & Polished Shafting • Drill Rod
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AMERICAN STEEL WAREHOUSE ASS'N
YOUR STEEL SERVICE CENTER

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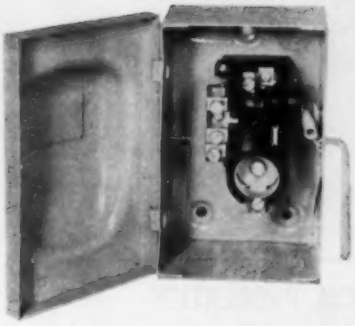
PRODUCT-DESIGN BRIEFS FROM DUREZ

- **New safety switch idea**
- **Phenolics in data processing**
- **What's hot in heat resistance**



A switch for fumblers

Ever try to change a fuse on a 30-amp switch in pitch darkness?

"No—and why should we?" retort the designers of many such useful devices. "Anyone who doesn't have a flashlight handy for these little emergencies is asking for trouble."

"Yes—and it was a horrible experience," breathes the designer of *this* switch. "Young son had used up all the flashlight batteries at Scout camp. Horrible. Gave me the idea for a switch *anybody* could re-fuse. It works, too."

This insight into the limitations of the average American householder is now helping to swell demand for the 30-amp safety switch pictured here. As you can see, the crossbar that actuates the contact has been moved to the back where it cannot get in the way of fumbling fingers.

To accommodate the new design, a one-piece block of Durez phenolic supplants a two-piece porcelain block. The more compact block of Durez allows extra hand-room for wiring the switch, and weighs less without loss of performance.

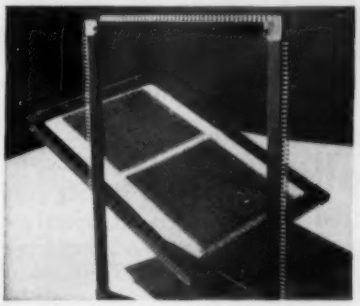
Have you an idea for a better electrical device? The odds are good that one of more than 200 Durez molding compounds can give it the exact mix of properties you want it to have. To narrow the uncertainty, see your molder or write us direct.

Jet-age abacus

With the help of Durez plastics, man can string words and numbers on wire like beads and pick them off again in millionths of a second.

His modern abacus is the IBM magnetic core memory. Thousands of tiny ferrite cores are wired into a frame like the one in the middle of this page. In an array of these core planes, stacked one atop another, electrical impulses alter the magnetic state of cores. A line of cores, some altered, some neutral, stands for a word or number, awaiting the impulse that releases it for calculation.

IBM engineers needed modern materials to bring this jet-age concept into being. The frame that supports the cores must be an excellent insulator. It must be free of internal stress that would cause warping or cracking. During assembly it must withstand the heat of dip soldering without losing its dimensions. Once assembled, it must not shrink or expand.



International Business Machines Corporation

For the core frame, designers and molder chose a mineral-filled Durez phenolic that delivers the ultimate in stability, heat resistance, dielectric strength, and moldability, meeting all requirements.

Other Durez phenolics prove their inborn versatility in the molded circuits of stepping switches, emitters, and zebra plates in new IBM accounting machines.

How much for a handle?

No, you don't really need a slide rule to design a coffeepot handle, but it helps.

This designer, at the moment, is not concerned at all with the compound-curve esthetics of coffeepot handles. He is simply figuring out how many handles his molder can make out of 1,000 pounds of which molding compound, and for how little money.

With the slide rule, it takes him only three and a half minutes to learn that his best bet for *this* handle is likely to be *Durez 1308*. Of the many mineral-filled phenolics we make, this one is in the lower gravity range. More pieces per dollar.

He has already checked into *1308's* other traits: rich black surface, uniform luster, good heat resistance (it withstands 450°F for short periods), low water absorption, flexural and tensile strengths OK.

His molder confirms the choice, for different reasons: he can get *1308* in four different plasticities, can plunger mold it, and it cures fast. Looks as if another good product is off the ground.

You don't design handles? Well, *1308* appears to fit into more heat-resistant applications than any comparable material ever developed: appliance and meter housings, wiring devices, tube bases, sockets, coil forms. The list goes on and on. But we'll stop so you can talk to your molder about *1308* for that next hot-spot job.

For more information on Durez materials, check here:

- ☐ 8-page Bulletin D400 lists properties, uses, design advantages of Durez thermosetting compounds, Hetron fire-retardant polyester resins, and Durez phenolic bonding resins.
- ☐ **"Durez Plastics News,"** mailed periodically, shows and describes latest uses of Durez materials.

Clip and mail to us with your name, title, company address. *(When requesting samples, please use business letterhead.)*

DUREZ® HOOKER CHEMICALS PLASTICS

PLASTICS DIVISION

HOOKER CHEMICAL CORPORATION

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KANIGEN®

The proved nickel alloy chemical plating—available only from General American and its licensees

KANIGEN is a chemically and metallurgically unique process for applying a hard, corrosion and abrasion resistant surface to most metals. KANIGEN is being used successfully for coating almost everything of any size—from the inside of a tank car to a tiny surgical needle—providing extreme uniformity of coating thickness even on complex shapes. Rack, jig or barrel plating may be used with KANIGEN.

You can rely on General American's integrity and experience and profit from its extensive research and development facilities. KANIGEN, of course, is patented to protect you from imitations.

KANIGEN is a trademark which identifies chemical nickel coating by General American Transportation Corporation and its licensees, the product resulting therefrom and compositions produced by them for use in chemical nickel coating.

KANIGEN is available from General American at East Chicago, Indiana; Sharon, Pennsylvania, and Compton, California, and from licensees in many cities. For further information, call or write.

PHYSICAL PROPERTIES

Specific gravity 7.9
Melting point ..... 1635 °F
Electrical resistivity
approximately 60 micro-ohms/cm/cm²
Coefficient of expansion
13 x 10^{-6} cm/cm per °C or
7.22 x 10^{-6} in/in per °F
Thermal conductivity
approximately 0.0105 to
0.0135 cal/cm sec °C (calculated)
Hardness
as plated—49 Rockwell C
heat treatable to 70 Rockwell C

World's largest production facilities for chemical nickel alloy plating on
Iron
Copper
Aluminum
Titanium
Beryllium
and their alloys

Pilot plant facilities are available for nickel alloy chemical plating on magnesium, uranium and non-metallics including thermosetting plastics, glass, ceramics.

Kanigen Division

GENERAL AMERICAN TRANSPORTATION CORPORATION

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Plexiglas...hardworking and handsome

for Ronson . . . PLEXIGLAS® acrylic plastic provides gleaming beauty and rugged strength in molded shaver housings, and sparkling color in point-of-sale signs.

for Pepsi Cola . . . PLEXIGLAS gives eye-catching attractiveness and outdoor durability to molded medallions on light look vending machines.

for You . . . PLEXIGLAS can add sales appeal to *your* products by making them more handsome or hardworking or both. Our design staff and technical representatives will be glad to tell you how. Write for our full color brochure, "PLEXIGLAS for Molded Parts".

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News about COATINGS FOR METALS

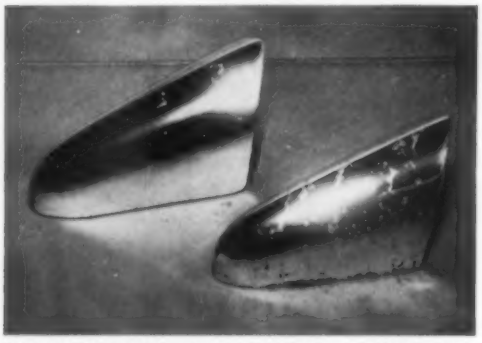
from Metal & Thermit Corporation

How to match chromium plate to design requirements

No longer is all chromium plate alike physically despite the fact that it remains the same *chemically*.

FOR MORE CORROSION RESISTANT BRIGHTWORK

The newest type of bright chromium plate offers much greater corrosion resistance than previously obtainable. It is free from the microscopic cracks inherent in ordinary chromium deposits and thereby prevents corrosives from contacting the underlying metal. For this reason, Unichrome *Bright* Crack-Free Chromium makes a major improvement in the corrosion resistance of decorative brightwork. It assures more uniform plate distribution and ample thicknesses in recesses. And with freedom from the cracks characteristic of ordinary chromium, Bright Crack-Free Chromium actually *reinforces* the resistance of the copper and nickel undercoats normally used.

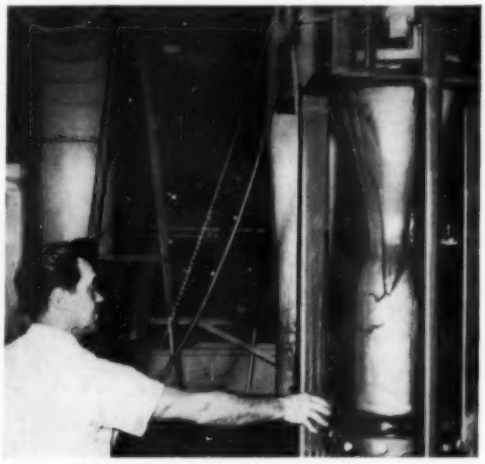


Bright Crack-Free Chromium promises to put an end to pitted and rusted auto brightwork. It plates without cracking, and eliminates pores by producing thicker bright deposits free from cracks. (Compared with ordinary chromium after 72-hour acetic acid salt spray test.)

TO OVERCOME CORROSION, WEAR, HEAT

Another new type of plate, Unichrome *Industrial* Crack-Free Chromium, delivers greatly improved corrosion, wear, and heat resistance for industrial or engineering-type applications. A ductile matte deposit free from corrosion-admitting cracks, it has excellent resistance to impact, abrasion, and thermal shock. Hardness ranges from 500 to 700 Knoop.

These properties of Unichrome Industrial Crack-Free Chromium are used to protect rocket engine assemblies subjected to hot, erosive, corrosive combustion gases. They also solve corrosion and wear problems on parts such as hydraulic rams, power steering shafts, high temperature molds, and washing machine shafts.



Resistance to thermal shock and superior corrosion resistance suit Unichrome Industrial Crack-Free Chromium for such uses as plating of rocket engine combustion chambers.

FOR OTHER APPLICATIONS

A third process, Unichrome SRHS® Chromium, has proved uniquely successful in applications where freedom from cracks is not required. It plates up to 80% faster than the ordinary chromium process, deposits chromium with less dulling and burning due to its unusually wide bright plate range. Its unique production advantages lead to an engineering benefit: more uniform control of plating quality.

NOTE: SRHS Chromium excels for plating stainless steel, enabling designers to "color-match" all brightwork on a product.

Send for bulletins giving more details. Write Metal & Thermit Corp., Rahway, N. J.

METAL & THERMIT
CORPORATION

For more information, turn to Reader Service card, circle No. 410

How special Armco Steels in vending machines help gain Balanced Design

High quality materials and *balanced design* are essential to long service life and trouble-free operation of vending machines. This is why Glascock Bros. Mfg. Co., Muncie, Indiana, manufacturer of a well-known pre-mix vendor, uses Armco Steels for many parts in their machines.

For example, parts that might be splashed by liquids are made of Armco ZINCGRIP® Steel (Bonderized and painted by Glascock Bros.). The special hot-dip zinc coating on the steel doesn't flake or peel . . . still protects the base metal against corrosion even if the paint is damaged.

To promote cleanliness, the cup-storage compartment is also made of Armco ZINCGRIP Steel. So are the covers for the coin mechanisms, as well as the baffle and outer shell for the refrigeration unit.

Armco Stainless Steel, Too

Parts that must withstand both corrosion and abrasion are made of Type 302 (Armco 18-8) Stainless Steel. And of course, all metal that comes into contact with the product is stainless, including the portable tanks.

For complete information on special Armco Steels that can help you give *your* products balanced design and new selling points, just write us at the address below. Our engineers will gladly consult with you on special problems. Armco Steel Corporation, 1389 Curtis Street, Middletown, Ohio.

ARMCO STEEL

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation • Southwest Steel Products

For more information, turn to Reader Service Card, circle No. 387

answering your demand for C

PORCELAIN ENAMEL

gives you greatest freedom of choice

RICH COLORS OR DELICATE PASTELS

You have practically unlimited choice of colors when you use Porcelain Enamel—from pastels to strong, rich hues. Outstanding effects can be had by using several colors, or two-tone or mottled designs for major areas or trim.

WON'T RUST, FADE OR STAIN—LASTS FOR LIFE!

Permanence is a virtue of Porcelain Enamel greatly appreciated by users of products made with this material. It withstands aging, weathering, corrosion, abrasion and abuse better than any other finish. Long life is an added sales point Porcelain Enamel can give your products.

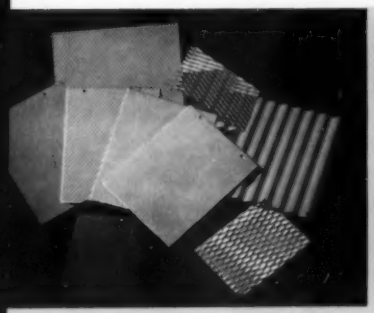
WIDE RANGE OF TEXTURES AND PATTERNS

The many attractive textures and patterns available in Porcelain Enamel give further opportunities to develop interesting designs. Many beautiful standard textures are available, and special ones can be developed. And the embossing or corrugating process makes the material stronger and more rigid!

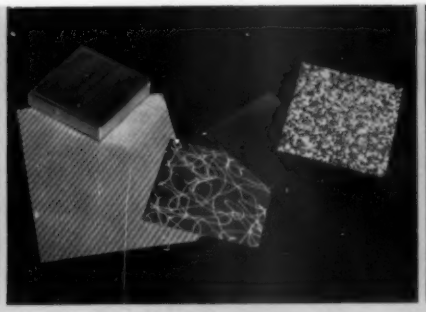
—AND EXCELLENT PHYSICAL AND CHEMICAL PROPERTIES

In addition to beauty and color, Porcelain Enamel provides many very useful engineering properties. It is glass-hard, steel-strong, and resistant to alcohol, chemicals, gases, moisture, flame, sunlight, thermal shock, abrasion, aging. Porcelain Enamel has a low coefficient of friction and high dielectric strength.

OLOR



INTERESTING EFFECTS, obtained with textured or patterned Porcelain Enamel, add greatly to the salability of many products. Corrugated and expanded metal are effective when finished with Porcelain Enamel.



COLORFUL PATTERNS give an endless array of designs that may be functional or decorative. Wood-grain and marble designs, pebbled and embossed surfaces give the designer wide latitude.

REFLECTIONS in these photographs show the difference between a highly glossy surface (left), semi-matte (center) and full matte. All are readily available in Porcelain Enamel.

GET THIS NEW FREE ENGINEERING FILE

Contains much technical material never before available. Return this coupon for your copy.

PORCELAIN ENAMEL INSTITUTE, INC.

Associations Building
1145 Nineteenth St., N. W.
Washington 6, D.C.

☐ Please send a copy of the new Engineering Data File.

☐ Please send information about possible application of Porcelain Enamel

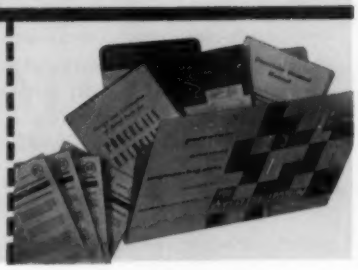
to_____
(type of product)

Name_____ Title_____

Company_____

Address_____

City_____ State_____
Please Print



For more information, turn to Reader Service card, circle No. 470

THE DODGE STEEL ladle
BUSINESS MAGAZINE EDITION
PUBLISHED BY DODGE STEEL COMPANY
6501 Tacony Street, Philadelphia 35, Pa.

How to obtain better, more efficient parts with foundry engineered steel castings

As a designer or purchaser of steel castings, you should know about the unique engineering assistance available to you from Dodge. You may take advantage of our facilities in three ways: First, to assist you with the proper design and specification of a proposed new casting; Second, to review your present castings in order to determine how they may be redesigned to save metal and increase strength; Third, to help you in converting other metals and forms to steel castings. Here is a typical example of the effectiveness of this service:

REDESIGNED VALVE YOKE

By using the redesigned Dodge cast steel valve yoke shown in Figure 1 below, Yarnall-Waring Company, Philadelphia, Pa., realizes a total saving in material and machining time of $15.81 per unit. And this excludes savings in tool and handling costs!

Before adopting steel castings, Yarnall-Waring Company machined all units. The yoke posts were made of #4140 material, and after machining, were heat treated for greater tensile strength. The heat treatment caused warping of the body and scaling of the threads—which in turn, made assembly and alignment difficult.

NEW ONE PIECE YOKE

Now, by using Dodge cast steel one piece yokes, Yarnall-Waring stocks one item rather than four. They save time across the board—purchasing, production, storage, handling and record keeping.

The change in design can be readily seen. Threaded yoke posts and nuts are eliminated, and the stocking and purchasing of seven 1⅛" taps and chasers are no longer necessary.

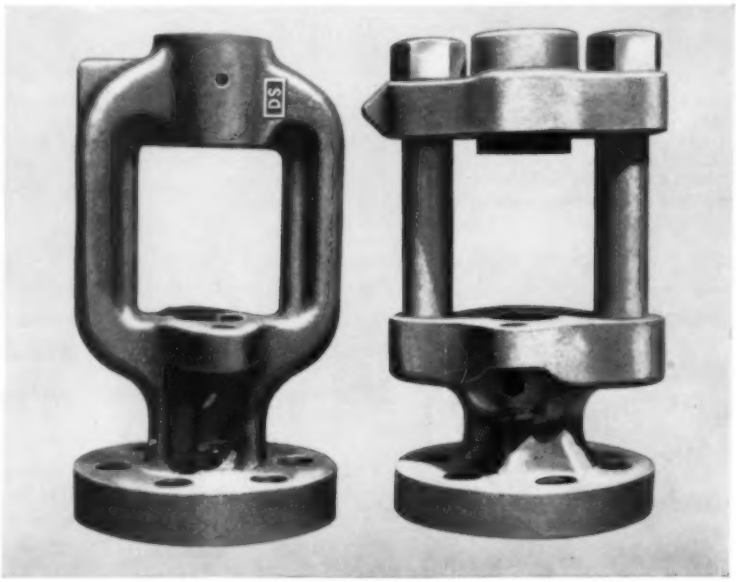
As for costs: material for the old style pillar-type yoke cost $17.58; material for the Dodge cast yoke, $8.32—a saving of $9.26! Machining time for the old style yoke cost $13.26, as compared to $6.71 for the Dodge Steel cast yoke—a saving of $6.55!

COMPLETE SERVICE

The best proof of the savings available to *your* company through the use of Dodge foundry engineering service is the experience of this manufacturer and others who have problems similar to yours. This timely and valuable service is ready to help you. May we study your problem?

Fig. 1 New Style

Fig. 2 Old Style



For more information, turn to Reader Service card, circle No. 437

For your specialized adhesive problems, call on *Ray-BOND*® adhesive specialists

FOR THESE AND 1001 OTHER APPLICATIONS, NEW R/M RAY-BOND ADHESIVES CAN BE TAILORED TO YOUR NEEDS

Many of your fabrication and assembly problems can be solved quickly and economically with the wide range of Ray-BOND thermosetting and thermoplastic adhesives manufactured by Raybestos-Manhattan. For special requirements, R/M will tailor special adhesives . . . designed to meet your own particular manufacturing techniques, the demands of the materials you are using, and the service conditions of the product itself.

Whichever you use, you can be sure that Ray-BOND will help you cut expenses, speed production, and simplify your operations. You can assemble complex shapes, bond parts of dissimilar materials, and do away with rivets and other fasteners. Your products will be able to withstand extremes of heat and cold and will have greater conductivity.

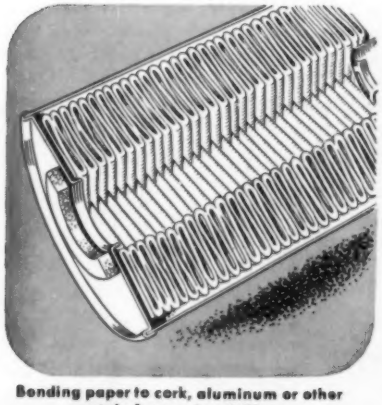
If bonding, laminating, sealing or coating can cut costs or improve production in your own operations, call on Raybestos-Manhattan engineers today.

R/M Bulletin No. 700 contains engineering information you will want on Ray-BOND adhesives, protective coatings and sealers. Write for your free copy.

Bonding cabinet top to base.

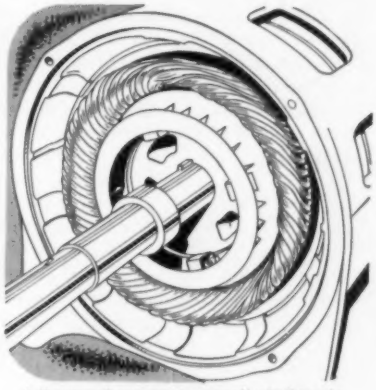
To create a firm bond on polyethylene plastic sewer and irrigation pipe.

Bonding friction materials to metal.



Bonding paper to cork, aluminum or other metals for use in oil filter.

Bonding laminated panels of new plastic refrigerator.



Adhesives keep armature coil windings in place under severe operating conditions.

RAYBESTOS-MANHATTAN, INC.

ADHESIVES DEPARTMENT: Bridgeport, Conn.

Chicago 31 • Detroit 2 • Cleveland 16 • Los Angeles 58

FACTORIES: Bridgeport, Conn.; Manheim, Pa.; Passaic, N.J.; No. Charleston, S.C.; Crawfordsville, Ind.; Neenah, Wis.; Paramount, Calif. Raybestos-Manhattan (Canada) Limited, Peterborough, Ontario, Canada

RAYBESTOS-MANHATTAN, INC., Industrial Adhesives • Brake Linings • Brake Blocks • Clutch Facings • Industrial Rubber • Engineered Plastics • Sintered Metal Products Rubber Covered Equipment • Asbestos Textiles • Laundry Pads and Covers • Packings • Abrasive and Diamond Wheels • Bowling Balls

For more information, turn to Reader Service card, circle No. 461

At Eastman

the question of color in plastics has over 39,000 creative answers

Eastman's Leadership in Color Creativity Has Produced Tenite Plastics in a Range of More than 39,000 Colors

To get an answer, you have to ask a question.

Users of Tenite plastics have asked enough questions since 1932 to make it necessary for Eastman color technologists to create formulations that will soon total 40,000 different colors and color effects.

While an untrained person may think of colors only in terms of the basic spectrum, his eyes usually are perceptive enough to detect even a minute variation when two colors are placed side by side. To such an eye, a new automobile interior would look disturbingly "wrong" if there were the least bit of difference between the color of its upholstery and its matched plastic appointments such as steering wheels, arm rests or control knobs.

Accurate color matches, therefore, are a vital concern to all manufacturers of plastic products that must be used in harmony with other colored materials of different surface texture, density or reflectivity such as painted wood, enameled metal, colored tiles or textiles. And, as color becomes more important in product design and merchandising because of its sales-stimulating effect, the attendant problem of proper color matching becomes even more critical.

Since 1932, when Eastman began to produce plastics, it has developed and kept on file, formulations for over 39,000 colors. This experience, plus Eastman's pre-eminence in color photography and textile dye technology, makes it possible for customers to depend on Eastman for the broadest range of colors available in the entire plastics industry.

In many instances, of course, customers can solve their color selection problems merely by consulting the extensive files of color chips available at every regional Tenite sales office. More extensive research in color matching can be carried out at the Tenite Color Laboratory in Kingsport, Tennessee. Here, the user of plastics is invited to work out his color problems in cooperation with a trained staff of color technicians.

Every day, some 15 to 20 requests for color matching are received by the Tenite Color Laboratory. These are submitted through regional Tenite sales representatives in the United States and Canada and through numerous Eastman affiliates abroad. The color samples submitted for matching include almost every known material—textiles, metals, tiles, wood, rubber, other plastics, paint and many more.

Four days usually are sufficient for the color technicians to make the match. For highly critical applications, as in the automotive industry, where there are many complicating factors of texture and density, the technician often submits several tentative matches.

When a sample arrives at Kingsport, the first step is to search for a possible match among the color chips in the Laboratory file. Frequently, one of the more than 39,000 chips of Tenite colors already developed may match the sample perfectly. If a match is found, the next step is to supply a trial batch

Thousands of colors on file

Milling the trial color

Accelerated weather testing

Color creativity depends on color research

of colored Tenite pellets to the customer.

When no formulation on file permits a match, the Laboratory proceeds to create a new color formulation. The technician first takes advantage of Eastman's 26 years of past color creativity—by selecting existing color chips of the nearest color matches and noting their colorant formulations. These provide him with helpful references for which there is no substitute. Drawing on the performance of colorants in many previous tests and in their actual finished or processed state, the technician avoids time-consuming delays of trial and error. He is assured that the colorants are easy to disperse, are compatible with the plastic mass and the plasticizer, and that they possess the maximum resistance to migration and the attacks of time, light, weather and temperature that limitations of availability will permit.

As he weighs out the colorants to make the new match, the technician varies the formulations of the nearest matches, adjusting them to approximate the exact color needed. When variegated, pearlescent or metallic effects are wanted, the technician must deal with the result of combining the components as well as with the color match. Often, he relies on intuition—disciplined by years of experience—to create a totally new and striking effect for the customer.

In the next operation, components of the formulation are blended together on milling rolls to insure homogeneous dispersion. Color chips are then molded from this test batch, and evaluation begins.

If surface coloration is the only critical factor, visual or "eyeball" inspection usually suffices to confirm the match. But even here, the technician must bring his highly specialized judgment into play. He must consider the visual implications of the two textures and their psychological effect in determining acceptance of the color in plastic as the proper match for the color in another material. In addition, over-all size and shape as well as contour of the original sample complicate his color matching efforts.

When light transmission is to play an important role in the end-product, the technician turns for conclusive guidance to the spectrophotometer. This precision instrument measures the length of light rays, and its findings permit formulation of properly translucent colors when transmission ratings must be held within limits dictated by the end-use.

If the color fails to duplicate the sample either by "eyeball" or spectrophotometer testing, the matching process starts all over again.

Finally, when the color technician is satisfied that the color match is accurate and that it can be supplied in commercial quantities within the prescribed limits of commercial acceptability, he makes a detailed record of the new formulation in the Tenite Color Laboratory file.

Careful detailing of the formulation is one of the most important steps in the color matching operation—for the success of full-scale production depends upon the accuracy with which the formulation has been recorded.

With the writing and filing of the formulation, another customer has had his color question answered—*and another color has been created by Eastman.*

The full story of the color resources that back up the Eastman plastics—Tenite Butyrate, Tenite Polyethylene and Tenite Acetate—is told in a 20-page booklet, "COLOR." For your free copy or more information on these plastics, write to EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

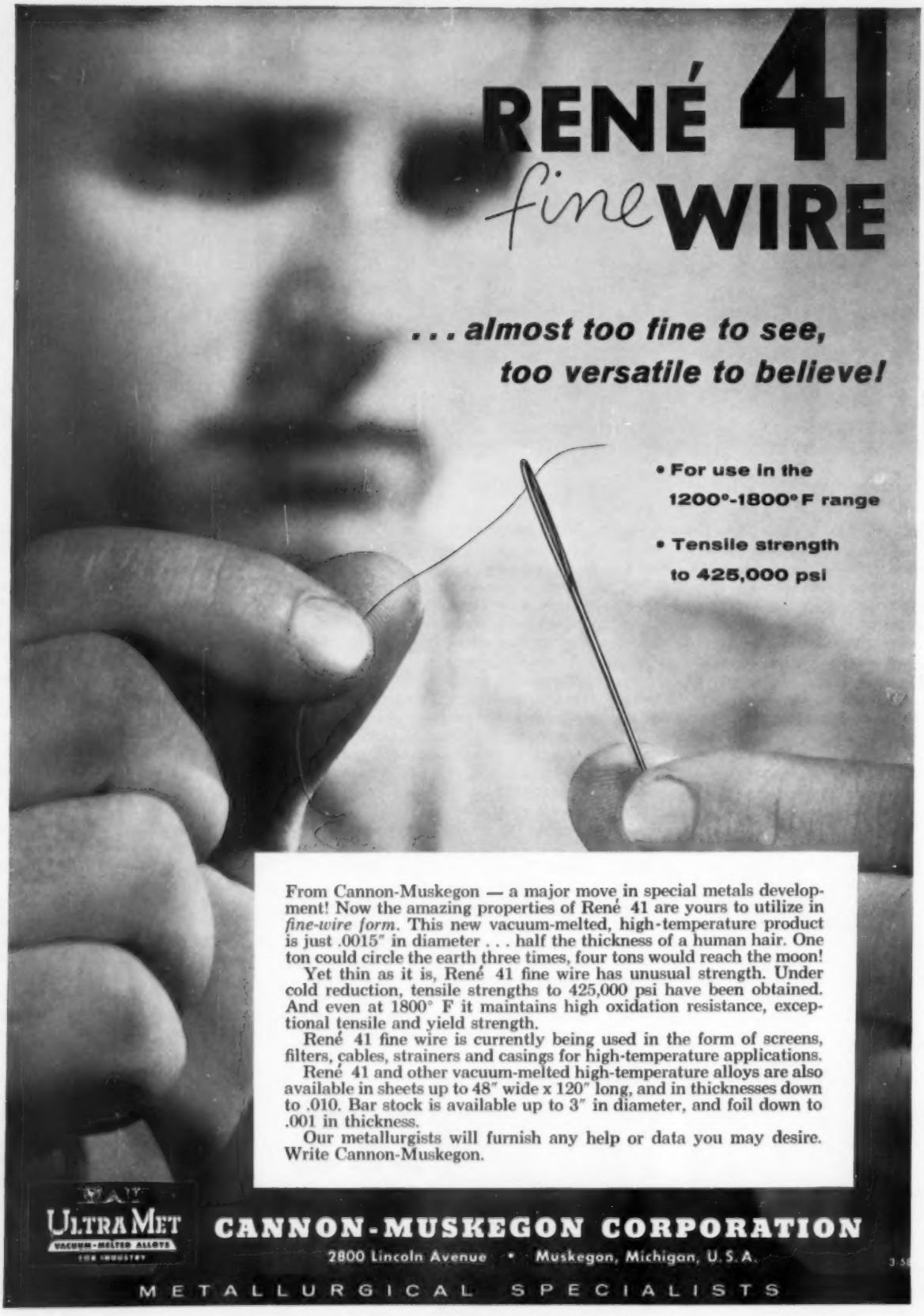
Judging the match

TENITE

BUTYRATE • POLYETHYLENE • ACETATE

Colorful plastics by Eastman

For more information, turn to Reader Service Card, circle No. 392


RENÉ 41
fine WIRE
. . . almost too fine to see,
too versatile to believe!
• For use in the 1200°-1800° F range
• Tensile strength to 425,000 psi
From Cannon-Muskegon — a major move in special metals development! Now the amazing properties of René 41 are yours to utilize in *fine-wire form*. This new vacuum-melted, high-temperature product is just .0015" in diameter . . . half the thickness of a human hair. One ton could circle the earth three times, four tons would reach the moon!
Yet thin as it is, René 41 fine wire has unusual strength. Under cold reduction, tensile strengths to 425,000 psi have been obtained. And even at 1800° F it maintains high oxidation resistance, exceptional tensile and yield strength.
René 41 fine wire is currently being used in the form of screens, filters, cables, strainers and casings for high-temperature applications.
René 41 and other vacuum-melted high-temperature alloys are also available in sheets up to 48" wide x 120" long, and in thicknesses down to .010. Bar stock is available up to 3" in diameter, and foil down to .001 in thickness.
Our metallurgists will furnish any help or data you may desire. Write Cannon-Muskegon.
ULTRA MET
VACUUM-MELTED ALLOYS
FOR INDUSTRY
CANNON-MUSKEGON CORPORATION
2800 Lincoln Avenue • Muskegon, Michigan, U.S.A.
METALLURGICAL SPECIALISTS

For more information, turn to Reader Service card, circle No. 460

A message to the designers
and producers of industrial equipment

HOW AN ENGINEER CAN BECOME HIS COMPANY'S BEST SALESMAN

Many of the most important users of industrial equipment are users of metallizing. More than 6000 of them today – a list that reads like a Bluebook of American industry. They use this modern process to maintain – *and improve* – the performance of equipment they buy. They have found through long experience that worn areas of machine parts can be made to give double and triple the ordinary service life by metallizing them with materials superior to the base metal. In many cases, new equipment is disassembled and critical parts metallized *before* they are used. These companies do this at very low cost.

You can provide the same advantages on a production basis at a fraction of that cost. Many *manufacturers* of industrial equipment are doing just that because it gives them a competitive sales point that they can use to advantage. One of these days an alert competitor of yours may get the same idea – *and the business.*

It will cost you nothing to find out if metallizing can improve the performance of your product, at low cost; give your company an important sales advantage. A comprehensive Engineering Data Bulletin on metallizing is yours for the asking – or better yet, a conference with an experienced, full-time, trained Metco field engineer in your territory who stands ready to advise users of metallizing as well as prospective users, how this low-cost process can go to work for them. Maybe it can go to work – profitably – for your company. Telephone, wire or write.

Free Bulletin No. 136
Basic Engineering Data on SPRAYED COATINGS of METALS and CERAMICS

METCO

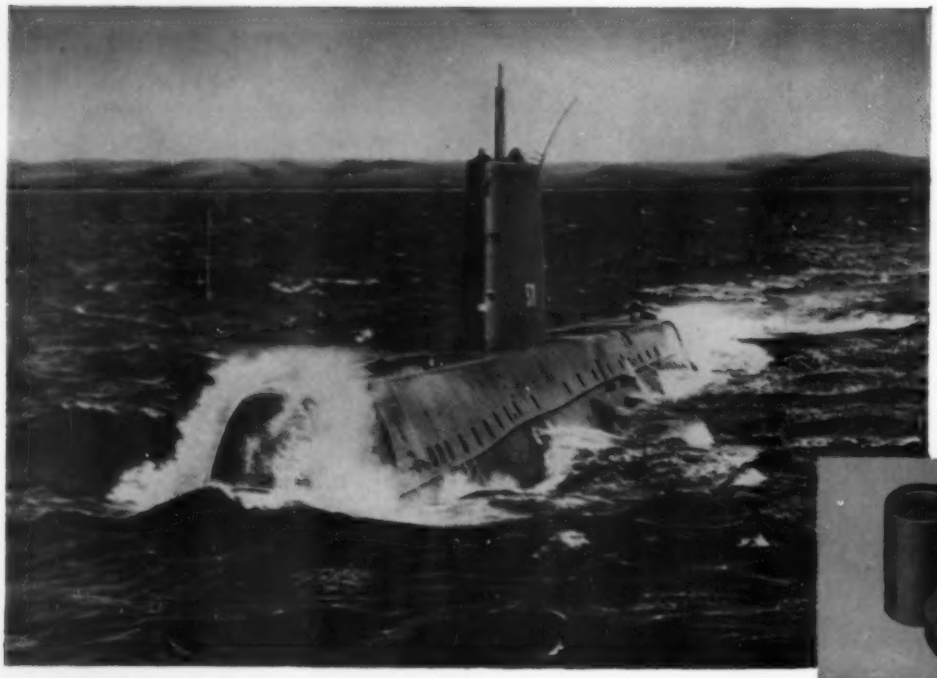
Metallizing Engineering Co., Inc.

1175 Prospect Ave., Westbury, L. I., New York • cable: METCO
Telephone: EDGEWOOD 4-1300
In Great Britain:
METALLIZING EQUIPMENT COMPANY, LTD.– Chobham near Woking, England

For more information, turn to Reader Service card, circle No. 428

Are your seals or bearings subject to difficult operating conditions?

GRAPHITAR® (Carbon Graphite) has the specific properties needed in difficult applications like these . . .

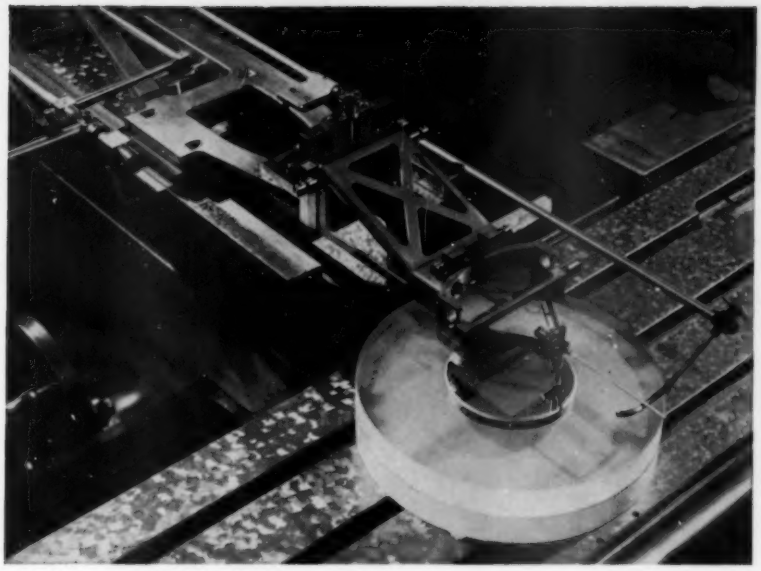


THE MOST IMPORTANT BEARING

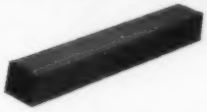
Dependability is vital in the power plant of the Navy's atomic submarine U.S.S. Nautilus which has steamed a total of about 50,000 miles of which approximately half has been submerged. In the reactor cooling system of the submarine, special "canned" motor pumps with integrated pump and drive motor were developed by Westinghouse. The bearings in these pumps, which are made of GRAPHITAR, must withstand high speeds, high temperatures, high pressures and must operate for indefinite periods of time without maintenance and with radioactive water as the only lubricant. Westinghouse Electric Corporation engineers—the builders of the Nautilus' atomic power-plant—find that GRAPHITAR is excellent for this difficult bearing application, because of its strength, durability, self-lubricating properties, and chemical inertness. If your design calls for superior bearings, consider the material that worked on such a demanding job.

THE UNITED STATES

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDERED METAL PARTS • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

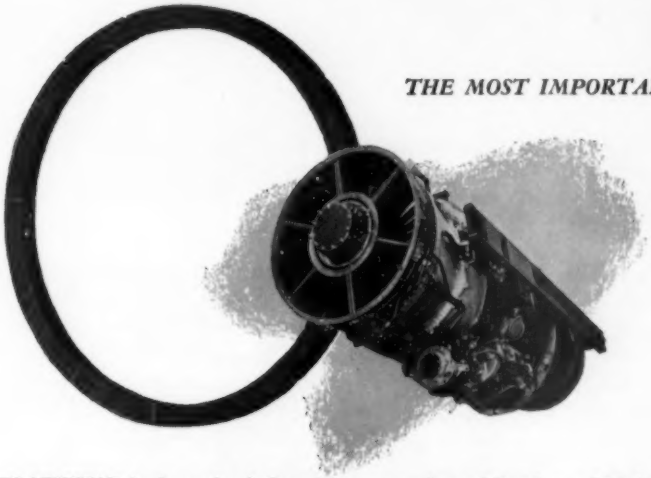


THE MOST EXACTING BEARING



The Bausch & Lomb Optical Co. of Rochester, N.Y., world renowned manufacturer of precision, scientific optical instruments, employs 10 GRAPHITAR bearings in its unique and highly specialized "ruling engine." The GRAPHITAR bearings provide dimensional stability within one-millionth of an inch for micro-inch accuracy in cutting 15,000-30,000 equidistant lines to the inch on 7" aluminized glass blanks to make diffraction gratings used by science and industry for spectroscopic analysis. Bausch & Lomb engineers have found that GRAPHITAR is unsurpassed as a bearing material where very close tolerances must be maintained and where frequent starting and stopping under heavy loads is a problem. These bearings have contributed greatly to the achievement of extreme accuracy in this application. If you require precision performance as was the case with a "ruling engine" why not use GRAPHITAR?

THE MOST IMPORTANT SEAL



GRAPHITAR is the main shaft seal in the Pratt & Whitney J57 turbojet engine which powers many of our new aircraft, including the huge Boeing B-52 Intercontinental Bomber, which has eight of these turbojets. Naturally, the J57 must perform with utter dependability. One of the components of the J57 is the air/oil seal of GRAPHITAR on the turbine main shaft, and this seal is subjected to tremendous shaft speeds, as well as other taxing physical conditions. GRAPHITAR parts can stand severe operation because they are strong and are virtually unaffected by extremes of speed, pressure, and temperature. If your product develops high speeds or other difficult physical stresses on its parts, perhaps GRAPHITAR components could give it more dependable operation.

THE TOUGHEST APPLICATION

Steel mills are famous for the rough, tough, heavy-duty jobs that they perform. In such difficult steel mill applications as bearings for shear and cut-off tables or coil and slab conveyors, metal-backed GRAPHITAR parts provide exceptional strength and durability. GRAPHITAR alone is a very strong bearing material, and when backed with metal has added resistance to shock. Because of its very low coefficient of friction, GRAPHITAR can operate under heavy loads at high speeds with no lubrication. Can the strength and superb bearing qualities of GRAPHITAR simplify your product design?

Get your copy of Engineering Bulletin No. 20.

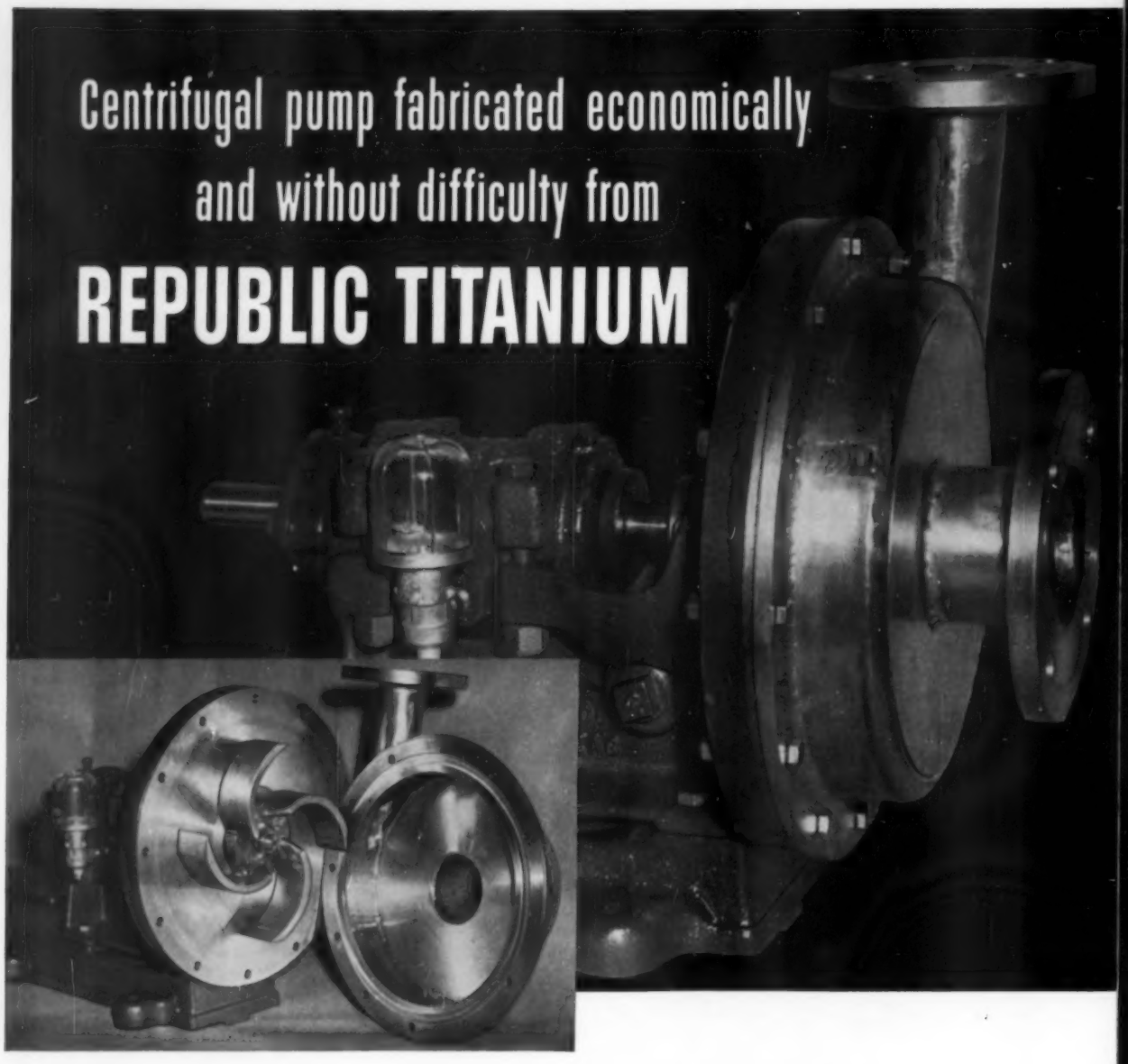
GRAPHITAR is compacted from carbon-graphite powders under great pressures, then furnaced at heats near 4500°F. It can be formed in relatively complex shapes and ground to tolerances as close as .0005". For more information on this strong, light, self-lubricating engineering material, write for our Engineering Bulletin No. 20.

218

GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 3, MICHIGAN

Centrifugal pump fabricated economically and without difficulty from REPUBLIC TITANIUM



Mission Manufacturing Company, Houston, Texas, has added a worthy companion to its full line of centrifugal pumps for corrosive and abrasive applications. Shielded-arc welding techniques now permit the use of titanium in its maximum corrosion-resistant form for particularly severe pumping applications.

The pump shown above was fabricated by shaping, welding in an inert gas atmosphere, and machining. It is being used by a leading chemical company to handle ferric chloride at temperatures of about 212°F. The finished pump, incorporating the exclusive Mission Concentric Casing, contains 34 pounds of Republic Titanium.

Performance ratings are essentially similar to those obtained for cast iron or corrosion-resistant alloys. Fewer pump sizes are required because the flat characteristics of Mission's impeller design provide a wide operating range and sustained efficiencies.

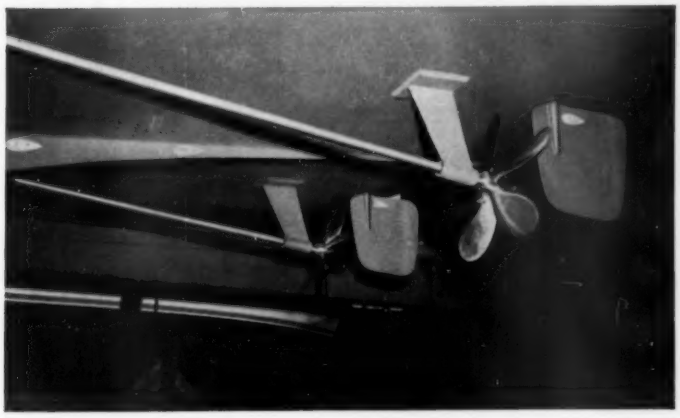
The entire fabricating operation was performed without difficulty and with little change in procedure as compared to other materials of construction.

Does this application of Republic Titanium spark an idea for your product that needs to be strong, lightweight, and corrosion-resistant? Republic Metallurgists and Machining Specialists will help you apply titanium's advantages now.

Republic produces commercially pure titanium and titanium alloys in ingots, billets, hot rolled and cold finished bars, plates, sheets, and strip. Mail the coupon for more information on these titanium forms, or for metallurgical and machining assistance.

SAVINGS IN MACHINING AND PRODUCTION COSTS of Ace Screw Extractors are obtained by the Henry L. Hanson Company with the help of Republic Cold Drawn Leaded Alloy Steels. Rolling of the extractor spirals formerly required several passes, each followed by an annealing operation. Now, with Republic Leaded Alloy, separate passes can be made deeper, reducing the total number of steps. And, because cold drawing improves the machinability of any given analysis, savings in machining costs are secured. Republic Alloys, Types 4140 and 4150, also provide a high degree of hardness and toughness. These properties in combination with scientific heat treating make the extractors practically unbreakable. Get all the facts on the advantages of Republic Cold Finished Alloy Steels. Mail the coupon today.

LOWER COSTS, IMPROVE QUALITY, INCREASE PRODUCTION with Republic Cold Drawn Special Sections. Because they are formed to the predominating cross-section of the part, Republic Special Sections eliminate or greatly reduce required machining. Results are faster output and lower cost. Also, since cold drawing improves the physical properties of any given analysis, completed parts are stronger and longer wearing. Other advantages may include improved appearance and simplified design. Send coupon for complete facts.



IMPROVED PRODUCT PERFORMANCE is reported by Roamer Steel Boats, Division of Chris-Craft Corporation, since switching to Republic Cold Finished Stainless Steel Bars. Vibration, a mechanical problem caused by out-of-true drive shafts, has been reduced to a minimum by Roamer through standardization of stainless shafts for their line of pleasure cruisers. The shafts are machined from uniformly straight Republic Cold Finished Stainless Steel Bars, Type 304. The bars meet Roamer's strict, maximum tolerance requirement of .006" runout in 72" of shafting. Stainless steel shafts also provide high strength and outstanding corrosion resistance. Republic specialists will help you use Cold Finished Stainless Steel Bars to best advantage. Mail coupon for more information.

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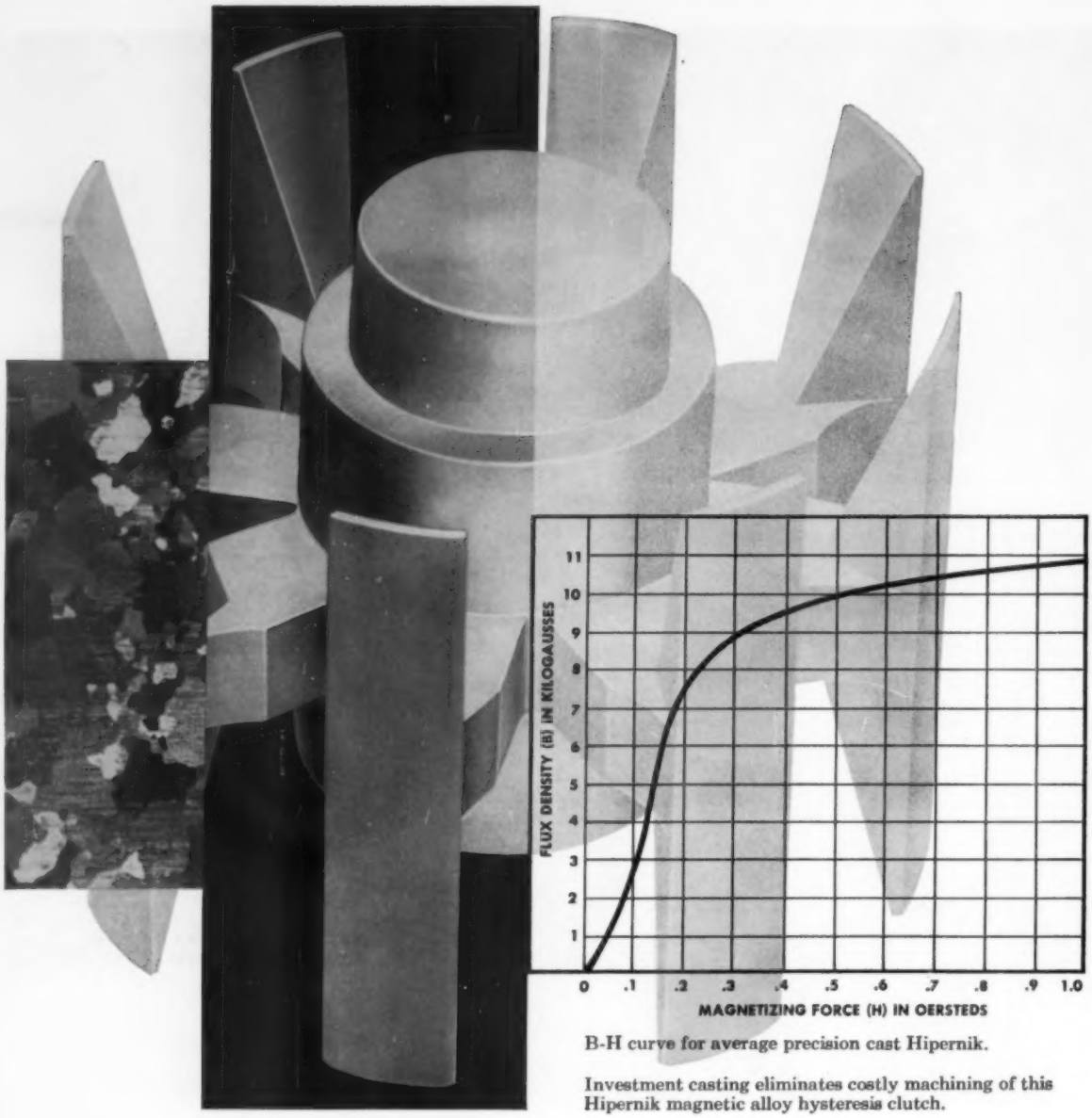

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Investment casting eliminates costly machining of this Hipernik magnetic alloy hysteresis clutch.

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The field of electronics has created special metal problems. The Westinghouse Metals Plant has accepted and solved some of these problems.

Cast Hipernik® is particularly adaptable to the requirements of missile control systems. Other applications in the electronic control and instrumentation fields are transformer cores, pole pieces, solenoids, torque motors, magnetic clutches and many special magnetic applications.

The Westinghouse Metals Plant may be able to cut your costs by eliminating unnecessary machining, yet delivering to you a completely finished component ready for assembly. This modern metals plant can furnish strip, sheet and bar stock in other magnetic and high temperature alloys. Write to: Westinghouse Metals Plant, Blairsville, Pennsylvania. Our latest bulletin on Hipernik will be sent to you by return mail. J-05005

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SPECIAL REPORTS ON FINISHING NON-FERROUS METALS

NUMBER I—Decorative, Corrosion-Resistant Finishing with Iridite

Chromate conversion coatings are well known and accepted throughout industry as an economical means of providing corrosion protection, a decorative finish or a good paint base for non-ferrous metals. However, continued developments are so rapid and widespread that many manufacturers may not be completely aware of the breadth of application of this type of finish. Hence, this digest of current information; to bring you up to date on the many ways in which you can combine salable appearance with durability in one finish at a competitive price advantage. Report II on paint base, corrosion-resistant finishes and Report III on chemically polished, corrosion-resistant finishes are available on request.

First, as a basis for this discussion, a "decorative" finish is considered as any chromate film that is used as a final finish in itself. It may be truly decorative in that its sole purpose is to enhance the beauty of the product. For example, a bright chrome-like finish or a pleasing bronze appearance are among the many effects that can be obtained. It may be functionally decorative in that it reduces reflectivity for camouflage purposes or provides a means of color-coding parts. But, in all cases, the Iridite films protect the metal against corrosive attack.

Iridite finishes are now available for all commercial forms of the more commonly used non-ferrous metals, including zinc, cadmium, aluminum, magnesium, silver, copper, brass and bronze. These films can produce a wide variety of pleasing appearances. The basic colors of the Iridite coatings are grouped below by metals.

ZINC and CADMIUM: Metallic bright, light iridescent, iridescent yellow, bronze, olive drab.

COPPER, BRASS, BRONZE: Metallic bright, yellow.

ALUMINUM ALLOYS: Clear, iridescent yellow, brown.

MAGNESIUM ALLOYS: Light brown, dark brown, black.

SILVER: Metallic bright.

In addition, many films can be modified by bleaching or by dyeing. Among the dye colors available are various shades of red, yellow, green, blue or black.

Depending upon the metal and the Iridite used, corrosion resistance of clear and bright films ranges from mild passivity to as high as 500 hours in salt-spray; on heavier dark films, salt-spray resistance ranges from approximately 100 to 1000 hours.

It is this combination of decorative and corrosion resistant properties that accounts for the widening use of Iridite finishes. For example, Iridites #4-73 and #4-75 (Cast-Zinc-Brite) make possible for the first time, a combination of lustrous chemical polishing of the as-cast surface of zinc die castings and good resistance to corrosion. Further, in many cases, sizeable savings in the cost of buffing and electroplating are realized.

WHAT IS IRIDITE®?

Briefly, Iridite is the tradename for a specialized line of chromate conversion finishes. They are generally applied by dip, some by brush or spray, at or near room temperature, with automatic equipment or manual finishing facilities. During application, a chemical reaction occurs that produces a thin (.00002" max.) gel-like, complex chromate film of a non-porous nature on the surface of the metal. This film is an integral part of the metal itself, thus cannot flake, chip or peel. No special equipment, exhaust systems or specially trained personnel are required.

On many steel parts, a simple system of zinc or cadmium plate and bright Iridite is used instead of more costly electroplated finishes to provide a bright, decorative and protective finish with tremendous savings in material, equipment and labor.

In finishing aluminum, where corrosion resistance or paint adherence is the prime consideration, the aircraft industry has all but abandoned the anodizing process in favor of recently developed chromate conversion coatings, among them Iridite #14 and #14-2 (Al-Coat). These formulations and their method of application can be varied to retain the original metallic appearance while providing acceptable corrosion resistance, or to produce a fully colored brown finish that offers exceptional corrosion protection. Again, time and manpower savings are astounding—one company saved at least $15,000 a year on maintenance of racks alone and another $40,000 on materials and labor in only nine months. In addition, of course, hundreds of thousands of dollars are saved by eliminating the need for expenditures for generators, heating equipment and racks.

Iridites are widely approved under both Armed Services and industrial specifications because of performance, low cost and savings of materials and equipment.

In planning or designing, you should consider the many other characteristics of Iridite finishes which may enter into the specific problem. In addition to having decorative and protective functions, these chromate coatings form an excellent base for organic finishes and bonding compounds. They have low electrical resistance. Some can be soldered and welded. The Iridite film itself does not affect the dimensional stability of close tolerance parts.

You can see then, that with the many factors to be considered, selection of the Iridite best suited to your product requires the services of a specialist. That's why Allied maintains a staff of competent Field Engineers—to help you select the Iridite to make your installation most efficient in improving the quality of your product. You'll find your Allied Field Engineer listed under "Plating Supplies" in your classified telephone book. Or, write direct and tell us your problem. Complete literature and data, as well as sample part processing, is available. Allied Research Products, Inc., 4004-06 E. Monument Street, Baltimore 5, Maryland.

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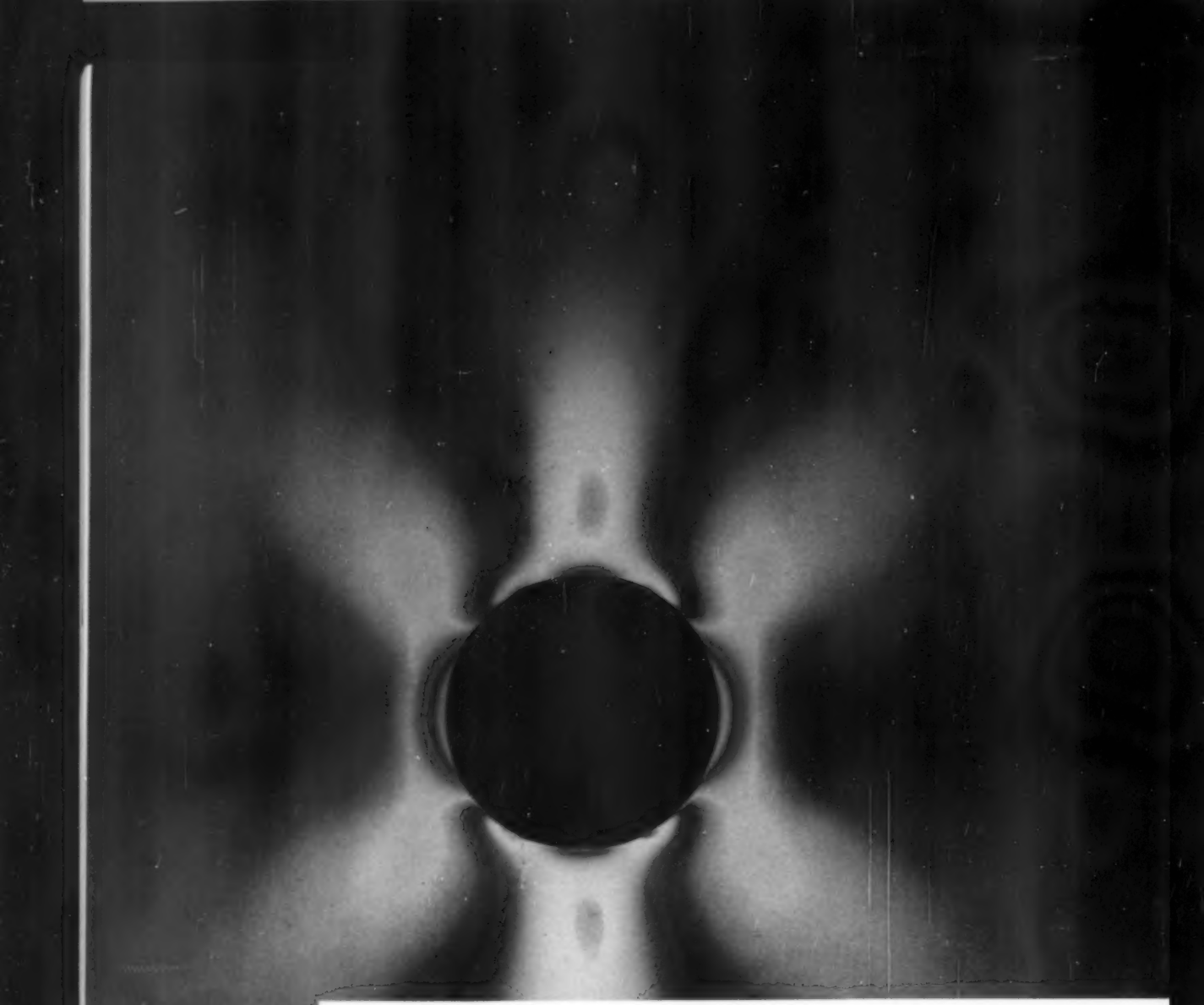

Photo-elastic stress patterns produced by models photographed with polarized light are one of the modern analytic tools available for ever-increasing perfection of Malleable iron castings.

Strength is Malleable

The strength crucial in spiraling the heave of diesels' pistons into unresistible power, in protecting lives as automobiles hurtle down endless highways, and in every link of chain that swings massive loads overhead, is yours to mold into tomorrow's dynamic engineering achievements with Malleable iron castings. Yet Malleable provides this strength in combination with toughness, producibility and economy that makes Malleable castings the finest, most versatile metal available.

For information or service, call on one of the progressive firms that identify themselves with this symbol—

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If you wish, you may inquire direct to the Malleable Castings Council, 1800 Union Commerce Building, Cleveland 14, Ohio, for information.

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How to Get More Strength Per Dollar with Malleable Castings

With few exceptions, strength is the most important single design requirement for a metal part. But in the commercial production of that part, the ultimate objective is to manufacture it at the lowest possible cost. Malleable iron castings take advantage of many factors to provide the greatest strength per dollar of any ferrous or non-ferrous metal.

Great Strength Range Available

From the wide range of standard (ferritic) and pearlitic Malleable irons available, a type may be selected that meets strength requirements ranging from 50,000 p. s. i. to 120,000 p. s. i. tensile.

Table No. 1 shows these strength values and other physical measures for 9 grades of Malleable. Note particularly how high yield strengths are in comparison to tensile strengths. Because yield strength is generally the measure of usable strength, this is especially important.

Also important is the uniformity of Malleable's strength. The heat treatment given all Malleable castings produces a unique metallurgical combination of strength, ductility, machinability and impact resistance. At the same time, it relieves internal stresses so that Malleable's strength cannot be machined away, nor will it be present in some parts but missing in others.

TABLE No. 1
TENSILE PROPERTIES—
A.S.T.M. MINIMUM SPECIFICATIONS

Standard and Pearlitic Malleable Irons

Designation	Tensile Strength p. s. i.	Yield Strength p. s. i.	Ratio of Tensile to Yield %
Standard			
35018	53,000	35,000	66
32510	50,000	32,500	65
Pearlitic			
45010	65,000	45,000	69
45007	68,000	45,000	66
48004	70,000	48,000	69
50007	75,000	50,000	67
53004	80,000	53,000	66
60003	80,000	60,000	75
80002	100,000	80,000	80

Strengths up to 135,000 p.s.i. tensile and 110,000 p.s.i. yield are produced commercially under individual producers' specifications.

Economy Due to Multiple Factors

Malleable's superior strength-cost ratio is due to a combination of the casting process, which puts the metal where you want it, and the inherent economy of Malleable iron. Also, whenever machining operations are involved, Malleable castings cut finished costs significantly. Being the most easily machined of all ferrous metals of similar hardness, the cost of the finished part can often be reduced to less than that of metals which cost less in the semi-finished stage.

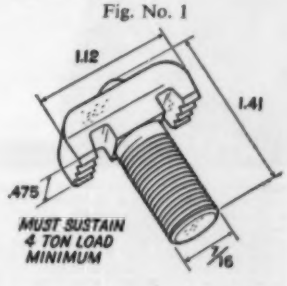
Malleable Provides Strength Plus Other Advantages

The T-bolt shown in Fig. 1 is used to assemble steel channel frames. Small but mighty, these 7/16" bolts hold 4 ton loads. The tensile strength requirements are 90,000 to 100,000 p. s. i., yet ductility must be good and tolerances must be held to ±.005" on the head width, and +.020", —.000" on the inside of the head.

In this application, pearlitic Malleable castings proved the only material consistently capable of sustaining loads over 8,000 pounds and meeting close tolerances in critical areas. At the same time, sufficient ductility was maintained to allow upsetting the spring retainer protrusion on the head.

The finished Malleable castings cost one third less than the next most satisfactory material. For both dynamic and static applications, today's Malleable castings are truly one of industry's finest engineering materials.

Fig. No. 1



Write for Free Data Unit

Data Unit 102-Strength, more fully describing Malleable's strength characteristics, is available for use by materials specifiers and users. For your copy, contact any member of the Malleable Castings Council or write to Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

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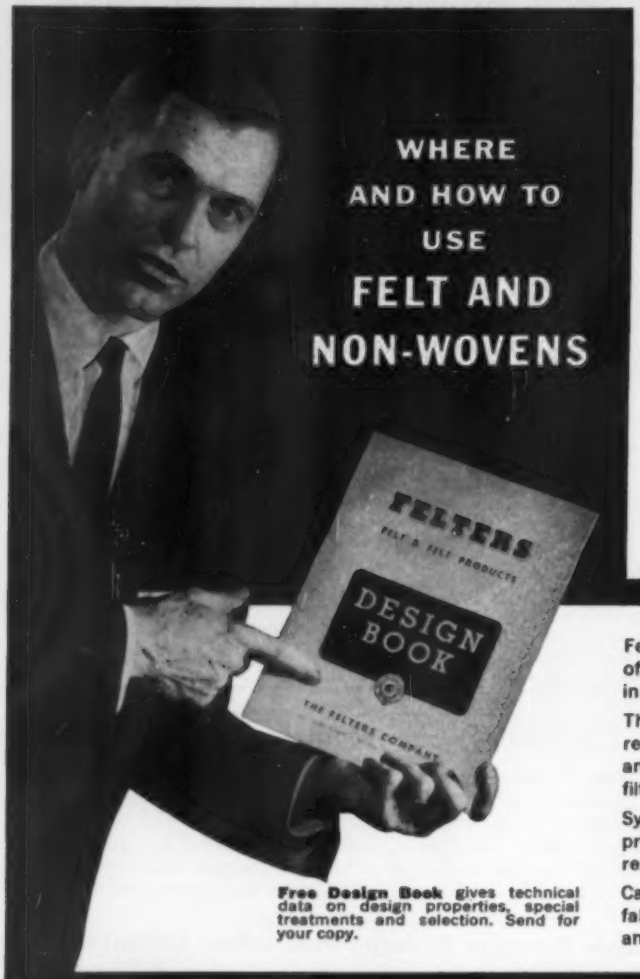


Free Design Book gives technical data on design properties, special treatments and selection. Send for your copy.

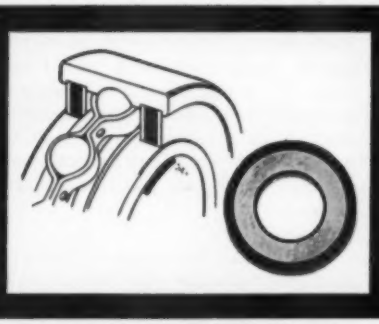
Felters' Cut Part serves as combination gasket, dust and light shield for [illegible] on Plymouth Pushbutton Shift Panel.

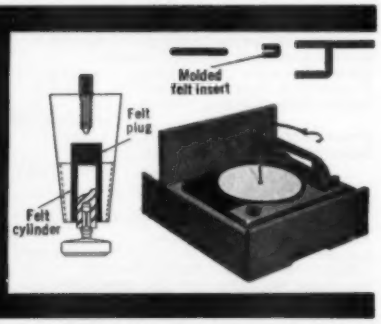
Felters' range of non-woven and felted-type fabrics offer wide combinations of characteristics not found in any other material.

These fabrics can be made tough, stiff or dense, as required. Also water repellent, flameproof, and moth and mildewproof. Ideal for absorptive wicking and filtering applications.

Synthetics, too, are giving non-wovens new uses and properties, particularly in smoothness, abrasion resistance, and long life.

Call on Felters for all types of felt and non-woven fabrics, including special treatments, impregnations and fiber mixes.





AllFab is a special Felters' non-woven fabric. Has thermoplastic resin binder and can be electronically stitched, sealed and embossed. Available in wide range of fiber combinations in thicknesses from 1/32" to 1" and more. Used for backing, filling, and plumping. Available with synthetic mixes such as Orlon®, with varying degrees of "loft."

Felt Pads (Prelubricated) prolong bearing life! Special tests show that oil saturated felt rings provide a built-in "slow bleeding" action to lubricate bearings. Functions over wide temperature range at speeds up to 10,000 rpm, without excessive starting friction at low temperature or poor stability at high temperature.

Hi-Fi Sets Use Felt in a number of places. Record changer drawers slide on aluminum channel with molded in felt insert. This provides light compression fit, eliminates resonant metal-to-metal contact, absorbs vibration and insures smooth action. Special felt lined piston legs eliminate floor vibration which affects performance.

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Easy operation—even an unskilled operator can get perfect readings. All controls conveniently grouped.

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DIAMOND "BRALE" PENETRATORS ... perfect testing every time

A perfect diamond penetrator is essential to accurate hardness testing. Since one point of hardness on the "ROCKWELL" scale represents only 80 millionths of an inch penetration—only 40 millionths on a Superficial tester—the slightest imperfection will cause a false reading.

Only *perfect* Wilson Diamond Brale Penetrators are sold. Each diamond is flawless, with no chips or cracks. It's cut to an exact shape. Microscopic inspection of every diamond—one at a time—assures this perfection—and assures you of accurate hardness testing every time.

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The TUKON Tester measures extremely shallow indentations. It's used, for instance, by manufacturers of watches, hairsprings, needles, and fine wire. Laboratories use the TUKON for tests on individual crystals or particles of microscopic size. Producers of coatings, film, ceramics, and many other materials have made good use of the TUKON.

Three models are available to meet your individual requirements. TUKON Testers use both the Knoop and 136° Diamond Pyramid Indenter. Each TUKON Tester is a self-contained hardness testing instrument— no accessory equipment is needed. Knife edges and levers of fixed length are used throughout for application of exact load and freedom from internal friction.

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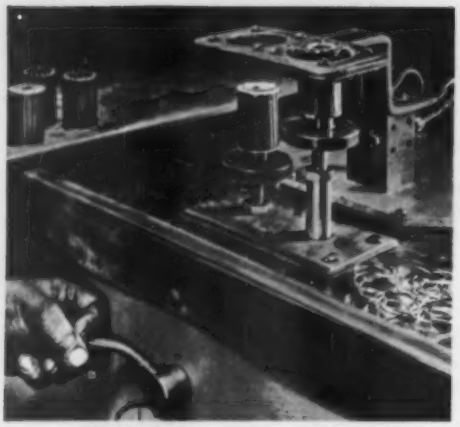
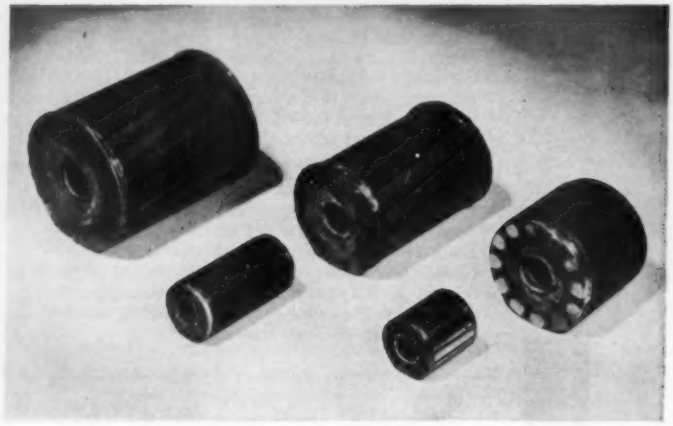


Handy & Harman Sil-Fos Silver Brazing is Used by Induction Motors Corp. in 5427 Different Motors



FIRST, BULLETIN 20

This informative booklet will get you off to a good start on the values, techniques and economies of low-temperature silver brazing. A copy awaits your request.

Induction Motors Corp. of Westbury, New York, and Maywood, California, has built an outstanding reputation as a designer and manufacturer of sub-fractional horsepower motors...for 5427 high performance reasons.

This large variety of motors, blowers and fans for an equally large variety of applications, stems from 15 basic motor frame sizes, depending on length, pole materials, windings, groove angles and the like.

Handy & Harman silver alloy brazing is concerned with brazing the rotors. Each rotor (whatever the size) is joined by a preformed ring of Handy & Harman SIL-FOS, by induction heating – at an alloy cost that is reckoned in pennies. For example, the alloy cost per ⅞" frame is two cents per joint, or four cents per complete assembly.

That's an example of the economics of silver alloy brazing. Performance requirements are quite another thing – and they are unquestionably stringent. Many of these motors are used in aircraft and missile work and must, of course, meet the most extreme environmental conditions.

Strength alone would be reason enough to discuss the merits of silver alloy brazing ... and to point out as a reason for its wide acceptance throughout industry. The facts are that there are many more benefits; gas- and leak-tightness, thermal and electrical conductivity, ductility, and production economy – are all *joint qualities* of silver alloy brazing. At any time, we will be happy to discuss any or all of these qualities (and others), as applied to your product or production method. The benefits are large and you can enjoy them.

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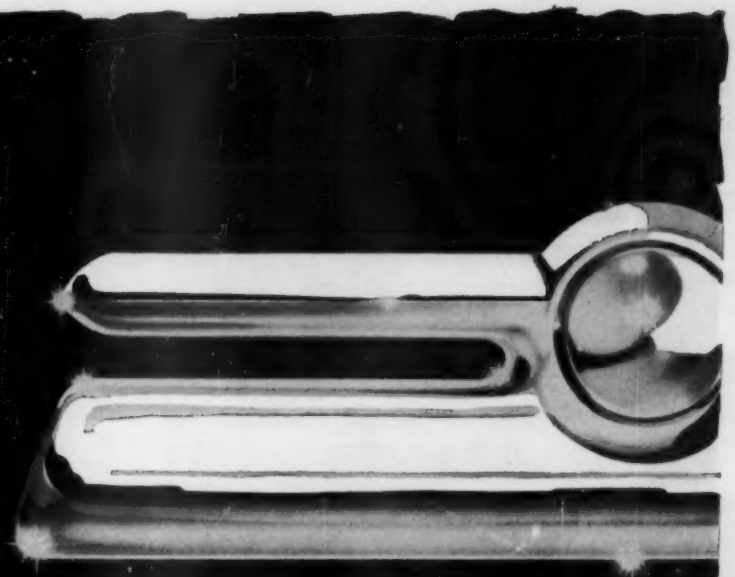
UNMATCHED CORROSION RESISTANCE



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Harshaw's research and development laboratory solved the problem of plating nickel on nickel. This, coupled with the use of a sulfur-free nickel plate and a bright nickel from a compatible bath, has made possible a Duplex deposit with unequalled corrosion resistance.

EXCELLENT CORROSION PROTECTION ACHIEVED THROUGH USE OF A SULFUR-FREE DEPOSIT

The Harshaw Chemical Company after years of research and development work was the first to find that a *sulfur-free* nickel offers greater corrosion resistance. This fact led to the development of the Harshaw Perflow nickel plating process. Further research showed that use of the sulfur-free Perflow nickel deposit as a base coating, followed by a bright nickel deposit from a *compatible* bath, would give a Duplex deposit with a further improvement of corrosion resistance. Performance data, by both accelerated tests and outdoor exposure, from leading automobile manufacturers and parts suppliers indicate that the Harshaw Perflow-Perglow Duplex nickel plate is comparable to and frequently better than, buffed gray nickel and is unequalled by any bright nickel.

MANY OTHER ADVANTAGES

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8. Simplified Control — Stable over extended periods of operation.
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10. Uniform Protective and Decorative plate on both steel and zinc die castings.

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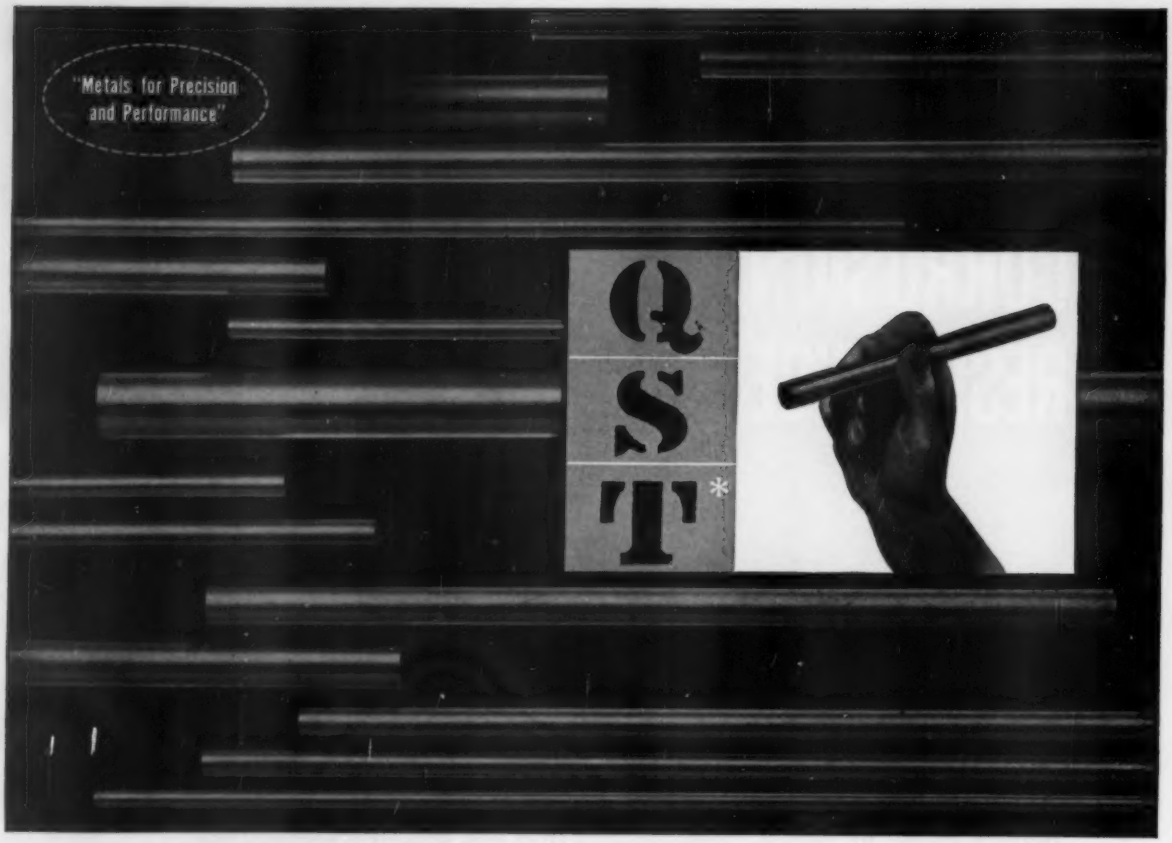

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What is this Quick Service Team? It's a corps of metallurgists and specialists who will provide *sound*, sure advice . . . qualified men in sales who *know* tubing, are pledged to give *fast* reliable service . . . and production experts who will push your job through for *quickest* possible delivery.

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STAINLESS STEEL TUBING Seamless, Welded & Drawn	Mechanical, Aircraft, Capillary, Hypodermic also NEW Stabilized and L grades, precipitation hardening alloys	0.008" to 1.000" OD 0.003" to 0.083" wall
NICKEL & NICKEL ALLOY TUBING	All standard grades	up to 1.000" OD 0.065" wall max
TUBULAR FABRICATED PARTS	Flanged, flared, milled, slotted, swaged, threaded	
GLASS-TO-METAL SEALING ALLOYS	Low expansion alloys for glass sealing applications	
CLAD METALS & COMPOSITE WIRES	Base metals & precious metals in various combinations.	
PLATINUM GROUP METALS	Fabricated products—chemicals	
CATALOGS, DATA SHEETS ON THE ABOVE SENT PROMPTLY ON REQUEST		

Get help in a hurry—start the Quick Service Team working for you. Contact Bishop by phone: Malvern 3100, by TWX: Malvern 570, or call your local steel warehouse.

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J. BISHOP & CO.
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THIS IS GLASS

A BULLETIN OF PRACTICAL NEW IDEAS FROM CORNING

POPPER THAT'S A STOPPER

It has been pointed out to us that every day the world survives, fewer are the chances that anything is the most, the biggest, the only, or the first.

But this corn popper *is a first*—to the best of our knowledge.

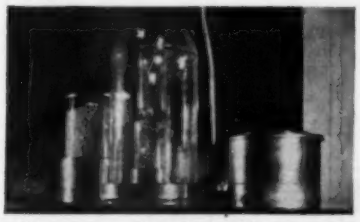
This machine pops corn with *hot* air—and all the action takes place *before your eyes*.

But that's putting the cart before the horse, because it was quite a number of moons ago when the designers at Electri-Cooker Division of General Foods were at the idea-developing stage.

They wanted a *new* way of popping corn. And they wanted to boost sales by having all the popping parts *visible*.

So, they developed a way of turning kernels into a fluffy delight with a *blast* of hot (about 200° F.) air. Then they turned to Corning.

And Corning in turn came up with a number of key components made from a PYREX brand glass. Included are a 17-inch display dome, 13-inch lamp chimney, and an 8-inch chamber for storing unpopped corn.



Why a PYREX brand glass? Because you can use it at elevated temperatures without worrying about thermal shock. (For example, PYREX brand glass No. 7740 has a linear coefficient of expansion of 32.5 x 10^{-7} in./in. between 0° and 300° C.)

Also, you can see through glass (an obvious but still extremely useful feature).

And glass is so easy to keep clean, there's no place for dirt to lodge in its *smooth* surface. Glass No. 7740 also is resistant to the attacks of most acids and alkalies and stands up well under distilled water.

You can find machines dispensing corn popped by hot air at Woolworth's, Grant's, Kresge's, McCrory's, Newberry's and Sears Roebuck & Company. You can find *glass* answers to one of your materials or component problems by coming to Corning.

You can get a head start by perusing "This Is Glass," a 64-page, well-illustrated primer. And/or ask for Bulletin B-83, a detailing of mechanical, thermal, electrical, and chemical properties for three of Corning's most popular types of glass. Use the coupon.

PURITY—KEY TO FUSED SILICA'S VERSATILITY

What material would you pick if you had the problem of accurate spectrum *transmission*, growing *high-purity* crystals, or building a component that would *not* darken under radiation?

The answer: Corning's 100% Fused Silica, an extremely versatile material that will handle these, as well as many other, specialized tasks. And the key to this material's versatility is its *extreme* purity.

Capacity to stand up to high temperatures, coupled with optical properties that yield excellent schlieren or shadowgraph quality, makes fused silica a natural for installation in wind tunnels for designing supersonic aircraft and missiles.

Optical purity and a high softening point (1585° C.) make Corning's 100% Fused Silica useful in wind tunnel windows.

Fused Silica also is used in ultrasonic delay lines, being well suited for handling delays ranging from 10 to 16,000 microseconds. More: You'll find this material possessed of high electrical breakdown resistance, low dielectric loss, and low expansion. And it is permeable to helium.

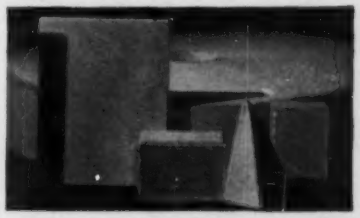
Uses (other than ultrasonic delay lines and windows for wind tunnels) include the following: windows for high-temperature applications, windows for hot cells, and the optical components for ultraviolet instruments.

All the facts are now available in spec sheet form. Check the coupon.

NEW—CELLULAR CERAMICS

Now, for the first time, from Corning's Cercor process, you can get thin-walled cellular ceramics.

These cellular ceramics are lightweight, resist oxidation, and have an extremely high surface area. Here is a sampling of Cercor products.



The material used to make these objects has 1500 square feet of surface area per cubic foot. Individual wall thickness averages only 0.005 inch; weight is only 30 pounds per cubic foot.

This material can withstand temperatures up to 1800° F. with virtually no thermal expansion, and can be operated continuously at 1290° F. At either temperature you don't have to worry about thermal shock or oxidation.

To provide additional strength, a ceramic coating can be bonded to the exterior of most cellular forms.

The composition of the Cercor materials may be changed to provide desired physical and chemical properties, and further development is expected to result in a broadening of potential configurations and product shapes.

Suggested uses so far include structures for use in gaseous heat exchangers, catalyst supports, burner plates, column packing, and acoustical filtering, flow control, insulation, and structural materials in high-temperature applications.

Inquiries invited. And/or ask for a just published bulletin detailing all pertinent data and characteristics.

CORNING MEANS RESEARCH IN GLASS

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Please send me: ☐ "This Is Glass"; ☐ Bulletin B-83; ☐ Fused Silica; ☐ CERCOR

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For more information, turn to Reader Service Card, circle No. 424

NEW LEADED STEELS FROM RYERSON

Now, machine parts faster than ever before

NEW LEDLOY 170 TUBING

average machining speed 170 surface feet per minute

Here's the fastest-machining steel tubing ever produced —and only Ryerson has it available for immediate shipment from stock. Ledloy® 170 is a cold drawn, seamless product of low carbon analysis with .15% to .35% lead added. It promises a minimum increase of 25% in productivity of machined parts or components. Sizes range from 1" to 2½" O.D. with maximum ⅜" wall thickness. Other sizes can be supplied promptly.

Part produced from Ledloy 170 Tubing for machining-comparison at National Metal Show.

NEW LEDLOY 375 BARS

average machining speed 375 surface feet per minute

This newest addition to Ryerson free-machining screw steel stocks is the world's fastest-machining steel. Assigning the figure 100 to B-1112 and using this as a base, Ledloy 375 has a machinability index of 205 plus. It rates about 64% higher than B-1113 and about 20% higher than Ledloy 300.

Ledloy 375 bars presently in Ryerson stocks include rounds in sizes from ¼" to 1", hexagons ¼" to ⅝".

Ask your Ryerson representative for complete details on these new steels. And call Ryerson for an unequaled selection of cold finished bars and tubing, including the largest stocks of Ledloy 300 (also known as Ledloy A) and Rycut® leaded alloys—the fastest machining in their carbon ranges.

MACHINING COMPARISON*
Ledloy 170 Tubing vs. Nonleaded Tubing

	Ledloy 170		MT-1015	
	Speeds	Feeds	Speeds	Feeds
Center drill	172 s.f.m.	.005"	110 s.f.m.	.005"
Form tool	172 s.f.m.	.0008"	110 s.f.m.	.0008"
Boring tool	172 s.f.m.	.007"	110 s.f.m.	.007"
Cutoff	172 s.f.m.	.0013"	110 s.f.m.	.0013"
Thread	27 s.f.m.	—	20 s.f.m.	—
Tap	18 s.f.m.	—	12 s.f.m.	—
Production time	35 seconds		49 seconds	

* As demonstrated at National Metal Show, Cleveland, 1958.

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Member of the INLAND Steel Family

Principal Products: Carbon, alloy and stainless steel — bars, structurals, plates, sheets, tubing — aluminum, industrial plastics, metalworking machinery, etc.

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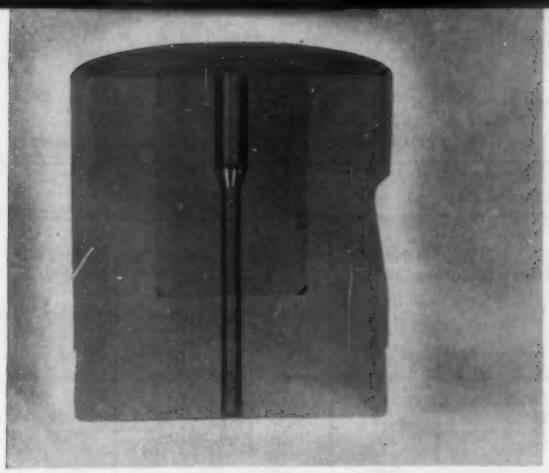
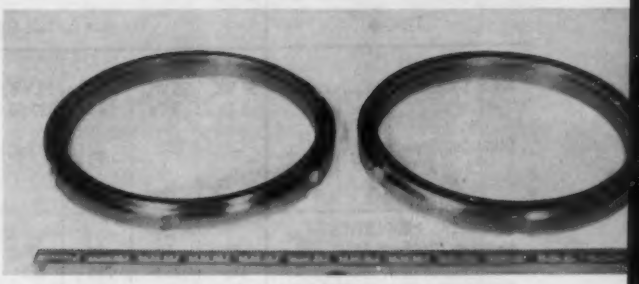
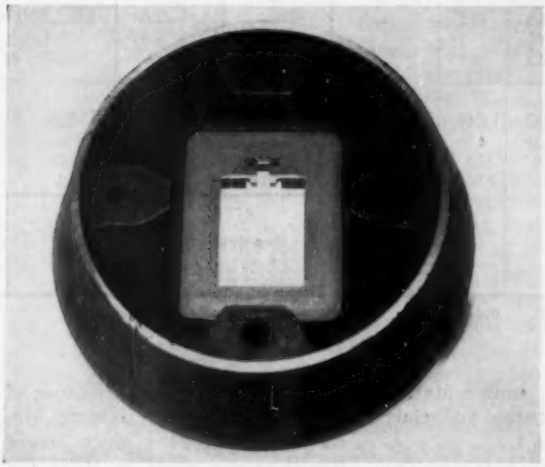


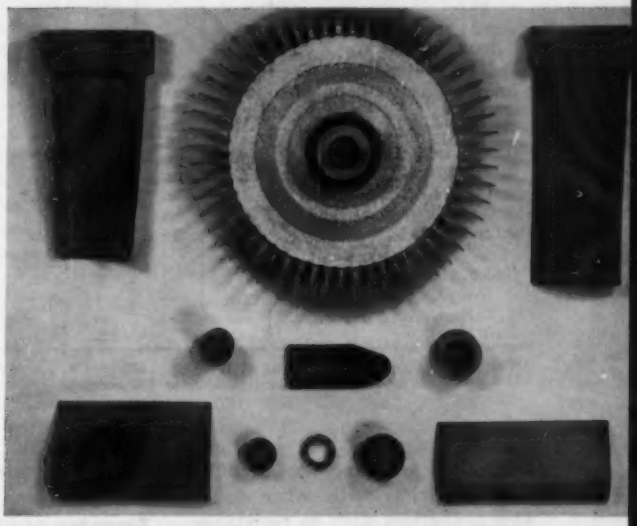
Heading dies *make use of tungsten carbide's high abrasion resistance, hardness and compressive strength.*



Rotating inface seal rings *for pumps in chemical processing equipment make use of chromium carbide's high wear resistance and outstanding corrosion resistance.*



Hot extrusion dies *of chromium carbide cermets have the high temperature strength and oxidation resistance required for extrusion of aluminum, brass or copper.*



Integral turbine wheels, *turbine buckets, stator vanes, valve seats and scalping tools make use of titanium carbide's high temperature strength.*

Why and where to use . . .

Carbide-Base Cermets

Each of the three major families of carbide-base cermets—tungsten, chromium and titanium carbide—offers a different combination of properties. Here is a quick survey of these durable metal-ceramic materials . . . their advantages and limitations.

by William W. Wellborn, *Firth Sterling, Inc.*

■ The high rigidity, compressive strength, hardness and abrasion resistance of tungsten carbide-cobalt materials—one of the first commercial cermets—have made them useful for a variety of non-cutting applications. More recently a number of other carbide-base cermets have been developed to meet increasingly severe design requirements. These materials

TABLE 1—TYPICAL PROPERTIES OF CARBIDE-BASE CERMETS

Type →	Tungsten Carbide-Cobalt						Chromium Carbide			
COMPOSITION, %										
Major Constituents	97 WC, 3 Co	95 WC, 5 Co	87 WC, 13 Co	75 WC, 20 Co	70 WC, 25 Co	70 WC, 30 Co	89 mixed CrC, 10 Ni	84 mixed CrC, 15 Ni	70 mixed CrC, 14 Ni	65 mixed CrC, 14 Ni
Other Constituents	—	—	—	5 TaC	5 TaC	—	1 Cu	1 Cu	1 Cu 15 TiC,	1 Cu, 20 TiC
MECHANICAL PROPERTIES										
Hardness (Rockwell A)	92	92	89	86	84	81	89	87	88	89
Trans Rupture Str, 1000 psi	175	233	275	275	275	300	100	120	100	100
Compressive Strength, 1000 psi										
75 F	458	450	414	391	354	325	480	422	—	—
1100 F	—	—	—	—	—	—	407	306	—	—
1500 F	—	—	—	—	—	—	—	—	—	—
Ten Str, 1000 psi; Elong, %										
75 F	—	—	—	—	—	—	36.4; 0	37.0; 0	—	—
1500 F	—	—	—	—	—	—	20.3; 0.2	41.8; 0.2	—	—
1800 F	—	—	—	—	—	—	—	—	—	—
Mod of Elast, 10^6 psi	97.7	—	79.5	72.0	64.5	60.2	—	—	—	—
Impact Str (Charpy unnotched), ft-lb	2.49	5.1	10.88	13.7	14.3	16.7	—	—	—	—
PHYSICAL PROPERTIES										
Density, lb/cu in	0.54	0.53	0.51	0.48	0.47	0.44	0.25	0.25	0.23	0.28
Coef of Ther Exp (avg), 10^{-6} per °F	2.6[b]	3.0[b]	3.6[b]	4.2[b]	4.3[b]	4.5[b]	6.3[c]	5.8[c]	5.9[c]	—
Ther Cond, Btu/hr/sq ft/°F/ft	28.3	31.8	29.5	23.7	17.9	16.4	—	—	—	—
Elec Cond, % ICAS	8.1	8.0	9.2	9.4	—	—	2.78	2.58	2.15	—
Oxidation Resistance, mg/sq cm[a]										
10 Hr	—	—	—	—	—	—	See curves, p 81			
25 Hr	—	—	—	—	—	—				
100 Hr	—	—	—	—	—	—				

[a]Weight gain after exposure to air at 1800 F. [b]68-1200 F. [c]68-576 F. [d]75-1500 F.
[e]This grade has best thermal shock resistance of TiC cermets.

combine many of the beneficial properties of tungsten carbide-base materials with other desirable properties such as resistance to oxidation and corrosive chemicals, high temperature strength, light weight and good bearing properties.

The three types of commercial carbide-base cermets discussed here are those most commonly used as structural materials. Briefly, the three types are:

1. Tungsten carbide-cobalt (WC-Co)—Though the properties of conventional WC-Co cermets are relatively well-known, recently developed compositions with higher proportions of cobalt than usual have higher impact strength than conventional WC-Co materials.

2. Chromium carbide-base cermets—Excellent resistance to oxidation and chemical attack.

3. Titanium carbide-base cermets—Excellent oxidation resistance and retention of strength at elevated temperatures.

Properties of representative grades of these three materials are shown in Table 1.

Tungsten carbide-cobalt cermets

As indicated above, the most recent improvement in WC-Co cermets has been the increase in impact strength gained by addition of more cobalt. Previously, the practical limit of cobalt content has been about 25% by weight; sagging and distortion during sintering occurred when larger amounts were added. Recent process developments now permit the addition of up to 35% cobalt, producing substantial improvements in impact strength. Properties of a typical grade containing 30% cobalt are shown in Table 1 compared with properties of several conventional grades.

Structural uses for WC-Co cermets include wire drawing dies, precision rolls, gages and valve parts. The higher impact grades are finding uses where die steels were formerly needed to withstand impact loading. Because of superior abrasion resistance, sintered carbides have much longer life than die steels in these applications. For example, a closed heading die made of a 70 WC-30%Co cermet has produced 3,500,000 stainless steel headings and is still in service; steel dies produced an average of 65,000 headings. No other carbide material has been successful in this operation.

Chromium carbide cermets

In general, chromium carbides have the lowest melting points of any of the stable carbides; the best general resistance to corrosive agents, as indicated in Table 2; phenomenal resistance to oxidation, as shown by the accompanying curves; relatively high thermal expansion; and relatively low density, as shown in Table 1.

There are three stable chromium carbides, which are generally mixed in any given composition. The three are: Cr_4C,

	Titanium Carbide				
	61.6 TiC, 22.2 Ni	48.6 TiC, 30.0 Ni	33.6 TiC, 39 Ni	55.1 TiC, 40 Ni	44.5 TiC, 50 Ni
	7.4 Co, 7.4 Cr, 1.4 Mo	10 Co, 10 Cr, 1.4 Mo	13 Co, 13 Cr, 1.4 Mo	4.9 Cr	5.5 Cr
	88	84	79	83	79
	210	220	220	180	95
	365	356	—	325	296
	—	—	—	—	—
	227	208	—	158	158
	26.2; 0	30.5; 0	—	32.9; 0	74.5; 0
	43.8; 1.5	—	—	51.4; 0	60.5; 0
	37.8; 2.4	—	—	41; 0	34.6;1.7
	56.1	50.9	46.2	53.0	50.6
	1.5	3.0	5.0	4.5	4.7
	0.22	0.23	0.25	0.23	0.24
	6.0[d]	6.0[d]	6.5[d]	6.0[d]	6.0[d]
	16.8	—	•	17.9	15.9
	—	—	—	—	—
	3.64[f]	2.89	—	8.7	2.1
	4.84	3.89	4.25	14.0	3.1
	11.0	7.5	6.38	31.5	7.6

containing 5.45% carbon; Cr_7C_3, containing 9% carbon; and Cr_3C_2, containing approximately 13% carbon. Most chromium carbide cermets use a nickel binder; for specific applications, other binders can be used.

Properties of chromium carbide cermets make them well suited for such applications as:

Valve parts—Comparative tests have shown that chromium carbide cermets resist erosion by high pressure steam more than 50 times as well as any other valve material. Valve liners and seats have been successfully operated at temperatures and pressures as high as 1800 F and 6000 psi. The materials have also been used successfully for oil well check valves, spray nozzles, bearing seal rings and pump rotors.

Gages—Such applications make use of chromium carbide-cermets' rigidity, abrasion resistance, corrosion resistance and ability to take a high polish. Also important is their similarity to steel in coefficient of thermal expansion.

Bearings—Hard grades of chromium carbide cermets running against softer ones have provided bearing properties superior to those of bearing bronze. Such bearings can be operated dry and at temperatures as high as 1800 F. The high compressive strength and rigidity of the materials provide extremely high load-carrying ability.

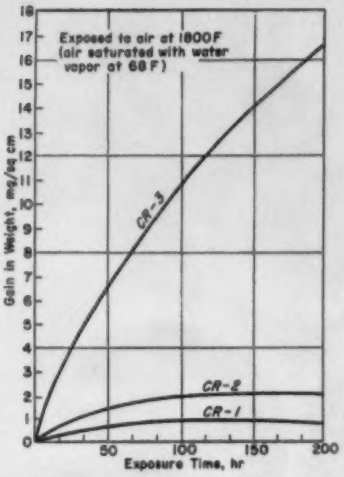
Nonmagnetic materials—Some compositions, such as the 65 CrC-14 Ni-1 Cu-20% WC grade shown in Table 1, can be made nonmagnetic and provide an excellent wear or bearing surface, control cam or integrator disk for sensitive electronic devices where magnetic materials cannot be tolerated.

TABLE 2—CORROSION RESISTANCE: CHROMIUM CARBIDE CERMETS VS OTHER MATERIALS[a]

Chemical ↓	Chromium Carbide Cermets[b]			94 WC-6 Co	WC-TaC-Co	WC-TiC-Co	18-8 Stainless Steel
	89-10	84-15	70-14				
Dilute H_2SO_4	B	B	B	C	C	C	D
Conc H_2SO_4	B	B	B	C	C	C	E
Conc HCl	C	C	C	D	D	D	E
Conc HNO_3	B	B	C	C	C	C	B
Aqua Regia	D	D	D	E	E	E	E
50% NaOH	A	B	B	B	B	B	A
Citric Acid	A	C	C	C	C	C	B
Lactic Acid	A	C	C	C	C	C	B
Acetone	A	A	A	A	A	A	A
Brine Solutions	A	B	B	B	B	B	B
Methane Gas (hot)	A	A	A	A	A	A	B
Sulfurated Oil	A	B	B	B	B	B	A

[a] A=complete resistance; B=good resistance; C=fair resistance; D=slight resistance; E=no resistance.

[b] Figures indicate weight percent: mixed chromium carbides-nickel binder. See Table 1 for complete compositions.



***Oxidation resistance** of three typical chromium carbides. CR-1 and CR-2 are the 89 and 84% carbide grades shown in Table 1; CR-3 is the 70% carbide grade.*

Titanium carbide cermets

Titanium carbide cermets are primarily used for high temperature applications. Their important properties are excellent retention of strength at high temperatures, good resistance to oxidation and thermal shock, and the high rigidity typical of sintered carbides.

TiC cermets usually utilize a nickel binder; specific desired properties are obtained by controlling the percentage of these principal ingredients and adding measured amounts of cobalt, chromium, chromium carbide or other additives. The compositional ranges given in Table 1 indicate amounts of additives found in commercial grades.

Titanium carbide cermets have been used in applications such as gas turbine nozzle vanes and buckets, integral turbine wheels, flash cutting tools, burner tips, flame nozzles, torch tips, hot upsetting anvils, hot spinning tools, tong pins, hot extrusion dies, hot piercing punches, hot mill roll guides, valves and valve seats, and thermocouple protection tubes.

Shape • Fasten • Engrave • Test • Materials with Explosives

by H. P. Tardif,
Metallurgist; Canadian Armament Research & Development Establishment

Hercules Powder Co.

Forming . . . deformation is fast

Explosive forming devices can develop speeds of 21,000 fps, compared to 26 fps for drop hammers, 2½ fps for drawing presses.

Explosive forming is done by using the rapidly generated gas pressure of explosives to form a metal part. Gas pressure and rate of deformation, important factors in the art of metal forming, can be controlled by carefully selecting the amount and type of explosive mixture or propellant.

Many companies are now developing new and specialized forming equipment utilizing explosives. It is believed that the development of explosive devices will result in: 1) smaller forming presses, 2) high speed deep drawing, and 3) forming tools lasting 10 to 20 times longer than they do now.

Advantages

In explosive forming, many shapes and materials can be formed that are impossible to form by conventional methods. The technique has been used to form such difficult materials as stainless steel, heat treatable steel and titanium.

Formability studies on 4130 steel and type 347 stainless steel show these metals have greater elongation and ductility in explosive forming than in conventional forming. Such studies show that explosive forming 1) doubles the elongation of full hard type 302 stainless steel, 2) increases the Rockwell hardness of type 302 stainless steel only from A72 to A74, and 3) increases the elongation of one type of aluminum alloy by 600%.

In addition, springback is considerably reduced, with better dimensional tolerances and great scrap reduction. A factor of great

importance is that the original equipment outlay required for small lot manufacturing of a given part is considerably reduced.

Three methods

To date, there have been three main approaches to explosive forming: 1) direct forming using cartridge gases or explosives, 2) hydraulic fluid forming using propellant gases, and 3) using a drop hammer actuated by propellant gases.

1. Direct forming of metal can be done in a device similar to the one shown schematically in Fig 1. In this device a charge is preloaded to produce a given pressure in a given volume. The device is currently being used by Lockheed Aircraft Corp. to expand type 347 stainless steel tubing (see Fig 2).

In the manufacture of a titanium inlet guide vane, heated dies are used to fold a titanium sheet 0.040 in. thick around a form having the shape of the vane. The sheet is held in the form for 15 or 20 sec at 800 to 1000 F to prevent springback. After heating, the folded vane is removed and seam welded at the edges. The vane is then placed between dies having an airfoil design. An explosive charge is set off in a chamber fitted onto the dies; gas pressure generated by the explosion escapes from the chamber into the titanium vane and bulges it outward to the shape of the dies.

Another method of direct explosive forming uses gas pressure from an explosion for cupping and drawing operations. This method is relatively unexplored but appears to have considerable merit.

Still another method uses a spherical-shaped charge (in conjunction with a parabolic reflector) and appears to have good possibilities for forming metals using half a die or no die at all.

2. Hydraulic fluid forming is done in a device similar to the one shown schematically in Fig 3. In hydraulic fluid forming, pressure generated by expanding gas from an explosive mixture is transmitted to an enclosed hydraulic fluid which in turn transmits pressure to the metal part being formed, forcing it to take the shape of a retaining die.

In manufacturing fan hubs by hydraulic fluid forming, two monel sheets are welded into cylinders, one fitting closely into the other, and dropped into a heavy laminated die having the shape of the part (see Fig 4). The cylindrical assembly is partly filled with water, a small charge of dynamite is placed at water level, and a cover is placed on top of the die. The dynamite is detonated, and gas pressure from the explosion forces the water to exert pressure on the monel cylinders, forcing them into the contours of the die.

In this particular application, explosive forming has four advantages over other forming methods: 1) it produces a part with uniform wall thickness; 2) it does not crack the metal; 3) it is considerably cheaper than metal spinning; and 4) it eliminates trimming and annealing.

3. Drop hammers use gases generated from an explosion to accelerate a piston and drop hammer to give a greater impulse to the metal being formed. This technique is said to permit the forming of parts heretofore impossible to form with a conventional drop hammer.

DIRECT FORMING

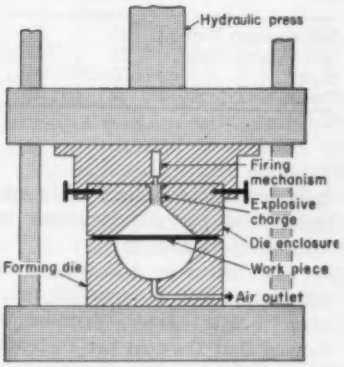
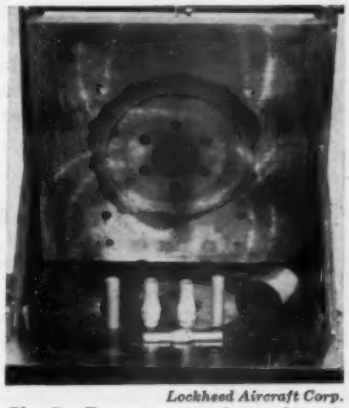


Fig 1—*Direct forming device.* *Lockheed Aircraft Corp.*



Lockheed Aircraft Corp.

Fig 2—*Type 347 stainless tubing is expanded in this device.*

HYDRAULIC FLUID FORMING

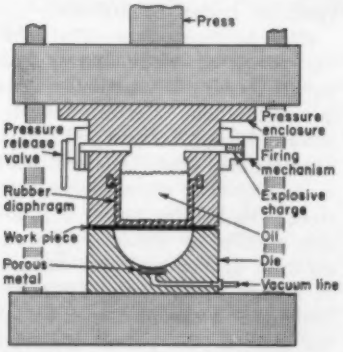


Fig 3—*Hydraulic fluid forming device.* *Lockheed Aircraft Corp.*

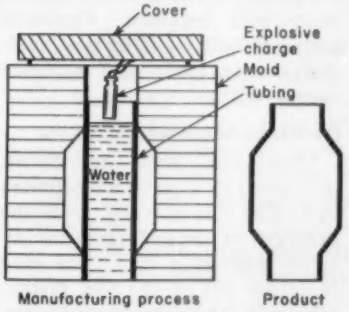


Fig 4—*Monel fan hub is made by hydraulic fluid forming.*

Punching . . . penetration is clean

Cartridge-actuated tools can quickly punch a hole in high strength steel without leaving cracks or burrs on the surface.

Punching holes in hard metallic materials like titanium and stainless steel can be done with a cartridge-actuated tool similar to the stud driver. In this device, captive pistons containing a punch are actuated by means of small charges of explosive powders placed in blank cartridges.

An application where explosive hole punching is particularly useful is punching a hole in high strength steel heat treated to 300,000 psi. The steel could not be drilled economically nor punched by conventional methods because of the formation of radial cracks. However, explosive punching has been done without leaving cracks or burrs on metal.

It appears that if the rate of hole punching exceeds the rate of crack propagation in the material, a clean hole is obtained.

Fastening . . . cartridge-actuated tools are portable

Explosive fastening devices can be used anywhere, require no air hose or electric extension cords.

Explosive fastening of metals can be done by using: 1) a fastener containing a small cavity filled with an explosive charge, such as an explosive rivet, or 2) a fastener shot from a cartridge-actuated tool, such as an "explosive" stud.

Explosive-containing fasteners

Explosive rivets are set into metal by means of a special riveting iron which heats the rivet head to about 300 F and causes detonation of an explosive charge (lead azide-tetrazene) in the cavity. The explosion causes the shank to expand throughout its length, forming a tight joint between two or more pieces of metal. Fig 5 shows how an explosive rivet looks before and after setting.

Explosive rivets can be set from one side, allowing blind riveting in tubular and other closed hollow members. Holes need not be drilled to precise tolerances because the rivet expands within the hole. Such rivets, made of steel, brass, copper and aluminum alloys, are presently being used in the construction of aircraft, buses and automobiles. Shear and tensile strengths for explosive rivets made of these materials have been reported by Hendrick. Similar data are given in an accompanying table.

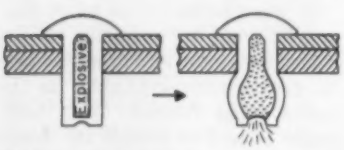


***Fig 5**—Explosive rivet as it looks before (left) and after (right) setting into metal.*

Explosive bolts and similar devices, such as explosive links and bolt thrusters, are used like ordinary bolts and links to hold assemblies together. However, they can also be made to split in two suddenly, releasing the assembly at a prescribed time. This is accomplished by means of a small explosive charge in a reduced portion of the shank of the bolt; when set off, the explosive separates the two ends of the bolt and the parts of the assembly previously held together. Explosive bolts are built to withstand various tensile loads and separate cleanly without fragments.

Cartridge-actuated fasteners

"Explosive" studs are driven into metal by a cartridge-actuated tool. The tool operates from the pressure of expanding gases directed against a stud. The stud is driven out of the tool instantaneously into place where its embedment gives high holding power. The stud driver, now used on a large scale, eliminates chipping or drilling of concrete and other materials and permits fastening in inaccessible locations.

STRENGTH OF RIVETS

Rivet Material ↓	Shear Str, 1000 psi	Ten Str, 1000 psi
5052 Aluminum Alloy...	15	23
5056 Aluminum Alloy...	25	28
Brass.....	32	46
Copper.....	21	35

Cost studies on a heating duct installation and a communication wire bridle ring installation showed that the cost per fastener was cut from $2.53 in inaccessible locations and $1.89 in accessible locations to 24¢. Time analysis studies showed that the work was done 50 times faster than by conventional fastening methods.

High holding power—The holding power of studs driven into metals by cartridge-actuated tools is considerable. Certain investigators (Ebert, Hofman and Seitz) have claimed that studs will hold up to 12,000 lb when driven into steel. The holding power is probably affected by diameter of stud, depth of penetration, and amount of charge in the gun. It is believed that a certain "welding" of the stud to the parent material produces high holding power plus good resistance to loosening by

pull or vibrations. Some evidence for this welding is that stress relieving before extraction does not appreciably reduce holding force; this implies that holding power is not due solely to friction during extraction.

Investigations have also shown that the end of the stud reaches a temperature above the Ac_3 of the steel during penetration and appears to be pressure welded to the surrounding material. Martensite is produced during subsequent cooling.

Bolts and studs are generally austempered to a Rockwell C hardness of 50 to 60. Using bolts hardened to Rockwell C52, Ebert et al obtained the following values of extraction strength in various metals:

Steel	0 to 4620 lb
Copper	550 to 3460 lb
Aluminum	1718 to 3740 lb

The variation of adhesive strength seems to decrease as the hardness of the base metal decreases. No other reasons were given for the occurrence of low values in steel, although a subsequent change in design gave higher values. The deformation of mechanical twins was also observed in the ferrite surrounding the bolt, indicating that the base material deforms at high rates.

Safety codes—If the base material is too hard there may be danger of rebound or fragmentation of the stud. Safety codes prohibit the use of stud drivers for shooting studs into hardened steel, high tensile steel, cast iron, granite and other hard and brittle materials.

Two Other Ways to Use High Energy Rates

High energy fuel and high pressure gas—rather than explosives—are used in two other metalworking processes to achieve high rates of energy transfer. One process is surface hardening; the other is rapid forming and cutting.

Surface hardening

In hardening, steel is heated by small rockets fueled with an oxygen-propane mixture that produces a jet having a temperature of 5400 F and a velocity of 4000 fps. Because of these unusual properties, the heat transfer rate obtained at the surface of a steel plate is four times that obtained with an open oxyacetylene flame.

Progressive linear hardening of flat bars of 4150 steel at 180 fps has produced Rockwell hardnesses as high as C68, with a case depth of 3/64 in. The steel is rapidly quenched by water jets after being heated, and the entire heating and cooling cycle can be accomplished in less than 2 sec.

Rapid heating by high energy materials allows the material to remain only a short time above the transformation temperature, thus preventing grain growth, producing thinner cases and permitting a more rapid quench by the cold metal beneath.

The higher hardnesses obtained by this method may be due to the rapid heating cycle, although the exact mechanism is not known. The method appears promising for applications where high surface hardness is required.

Rapid forming, cutting

A new metalworking machine called Dynapak uses gas under high pressure as the driving force. One model of the machine is capable of producing 40,000 ft-lb of energy at velocities of more than 200 fps.

The machine can be used for forging, forming, extruding, compacting, shearing and blanking of metals and other materials. It is now commercially available from Convair, Div. of General Dynamics Corp., 1243 Transit Ave., Pomona, Calif. (More details in a forthcoming issue.)

Engraving . . . reproduction is accurate

Carefully planned detonation can reproduce very accurate designs on metal surfaces.

Two methods have been developed for engraving metals with explosives: one uses the shaped charge effect and the other uses a stencil interposed between an explosive and a metal plate.

1. *Shaped charge:* In this method, a bas-relief is carved at one end of a slab of explosive and this face put in contact with a metal plate. Detonation of the explosive transfers the design onto the plate. (See also box on p 87).

2. *Stencil:* In this method, a stencil bearing the design is interposed between a plane surface of explosive and a metal plate. The explosive force is transmitted better through the open parts of the stencil than through the solid part, producing very accurate designs.

Considerable work has been done by J. H. Cook on this method of engraving. He found that for best results the detonation wave through the explosive should meet the metal plate normally over its

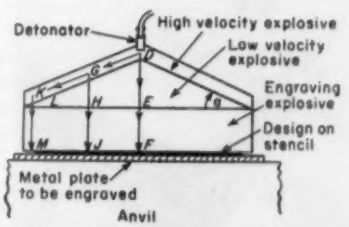


***Fig 6**—Engraving is done in a device similar to this one. Explosive charges are designed so that the engraving explosive is initiated simultaneously over its entire surface.*

entire surface. Simultaneous initiation at many points over the surface of the explosive will not give good results because of shock wave interaction.

The arrangement shown schematically in Fig 6 produces a good engraving. As shown, the conical portion of the explosive charge is made up of a thin top layer of a high velocity explosive and a bulk charge of a low velocity explosive. The sine of the angle a is the ratio of the detonating velocity of the two explosives. Under these arrangements, the time interval between firing of the detonator and initiation of point L will be the same as that for initiation of points H, E, etc., so that the explosive will be initiated simultaneously over its entire surface, producing a plane shock wave suitable for engraving.

Testing . . . test methods are simple

Explosive test methods require no complicated or expensive equipment such as large structural test models.

In recent years a great deal of interest has been shown in the use of explosives for testing metals. In England, explosives are now being used to test welded steel structures under water. Elsewhere, explosives are being used to study the internal structure of steel ingots: an explosive charge splits the ingot in two lengthwise, permitting observation of the primary structure.

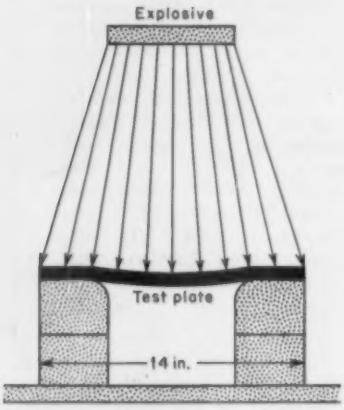


***Fig 7**—Bulge test is performed by placing a test plate over a die and loading it by the force of an explosive suspended in air over the plate.*

***Fig 8**—Bulged plate as it looks after explosion (bottom). Die (top) is used to support the steel plate.*

Bulge test

The explosive bulge test is performed at temperatures of –100 F to 200 F and is used to evaluate metal for crack initiation and crack propagation characteristics. The bulge test also provides a means of testing plates under contolled biaxial stress conditions.

A modification of the bulge test, called the crack starter test, is performed by depositing a weld on the lower surface of the plate. The test is used in studying crack initiation and propagation characteristics above and below the nil-ductility transition temperature.

How it works: A test piece, 14 x 14 in. or slightly larger, is placed over a die and loaded by the force of the controlled detonation of an explosive charge suspended in air over the test plate (see Fig 7). An explosive is used because it develops the high pressures necessary to bulge thick plates. The unsupported area of the plate is approximately 28% of the total area; the remainder of the plate is effectively clamped to the die by the gas pressure of the explosion and remains flat over the supported area. Fig 8 shows what a test plate looks like after an explosion.

What it shows: An example of the kind of information that can be obtained from the bulge test is the effect of welds in plates. Tests have shown that: 1) the presence of welds affects quite appreciably the strain state in bulged plates; 2) mild steel weldments have greater tendency to fracture when weld reinforcement remains in place than do those with the welds ground flush; 3) weld reinforcement causes a rise of about 80°F in transition temperature; 4) performance of pearlitic steel weldments is determined by the weld rather than by the heat affected zone; and 5) notch toughness and flow strength of the weld appear to be the major controlling factors in the performance of pearlitic steel weldments.

Triaxial loading test

Another explosive test method has been developed whereby the resistance of a steel plate to fracture under combined stresses and high rates of strain can be evaluated. In fact, it is said to be the only practical method available for obtaining uniform triaxial loading on comparatively large volumes of material.

The test is performed by the static detonation of a controlled explosive charge in direct contact with the specimen being tested. The test set-up is otherwise similar to that of the explosive bulge test.

The critical part of the test is the accurate reproducibility of the detonating velocity, since the energy varies as the square of the velocity. Tests are performed just

The Shaped Charge: How It Can Be Used

When an explosive charge is hollowed out at one end and this end placed against a target, the damage produced is greater than when the charge is flat-ended. If a thin metal liner, usually conical, is placed in this cavity, the destructive effect is considerably increased. The shock wave produced by the detonation of the explosive collapses the metal liner which forms a high velocity jet with great penetrating power (see accompanying sketch).

High deformation rates

The shaped charge can be used to study the deformation of metals under high rates of strain. During collapse of the liner, strain rates of 10^5 per sec are obtained; fractional microsecond flash radiography is used to study the behavior of the metal under these conditions. Effects of crystallographic structure and temperature on the ductile or brittle behavior of the jet show that face-centered cubic metals give a more ductile jet than body-centered cubic or hexagonal structures.

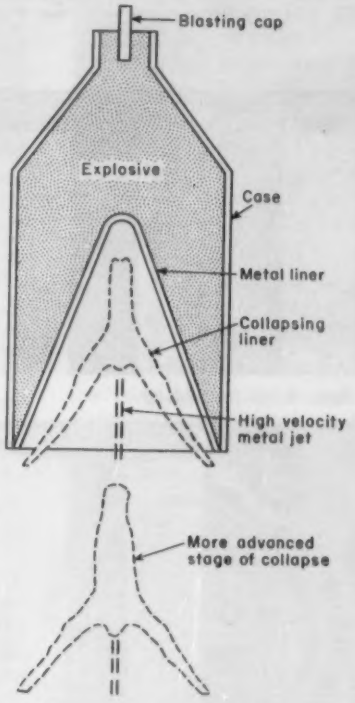
Metallographic studies of cast iron liners after deformation show that under conditions of high pressure and high strain, ordinary gray cast iron, which is considered a brittle material, behaves in a very ductile manner. A thin conical cast iron liner deformed in 10 to 15 μsec to form a solid slug. In parts of the slug, graphite flakes and pearlite grains were deformed to very narrow and thin bands in the direction of the axis of the slug or original conical liner.

The shaped charge has been used to study changes taking place in the structure of 1020 steel. A hardness curve similar to the one shown below can be obtained by measuring hardness at various distances from the profile of a crater left in the metal after penetration by a shaped charge. Plateaus in the curve are probably caused by areas in the steel containing a large proportion of grains with four, three, two and one twinning direction. Microscopic examination has shown a considerable amount of mechanical twins in the ferrite, indicating high rates of deformation.

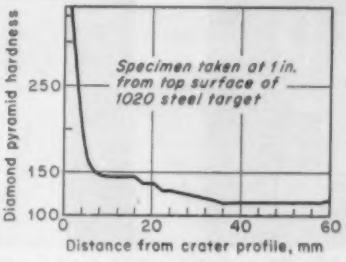
High velocities

The shaped charge has also been used to accelerate metallic and plastic pellets to high velocities. A conical-shaped pellet is placed at one end of a cylinder of explosive and propelled in a direction along the axis of the cylinder at velocities up to 19,685 fps. Light spectra emitted by the pellets during high velocity flight can be obtained, and information such as temperature, excitation, ionization and chemical reaction of materials derived.

In addition, the shaped charge has been used to study the mechanisms of cratering and perforation of thin targets—of great importance in the development of satellites and missiles.



High velocity metal jet *is produced by shock wave from liner.*



Hardness *plateaus in 1020 steel after perforation by a shaped charge.*

below the critical velocity at which spalling of the steel is produced. A detonation velocity of 3250 m per sec is generally used when testing steel plates.

A plane wave detonator (see section on engraving, p 85) is used in the test so that the shock wave reaches the face of the specimen simultaneously over the entire area.

With this method it has been possible to determine the effects of stress relieving, preheating, electrode composition and other welding variables on performance of steel plates. In the test, various regions of the plate and weld can be evaluated simultaneously, indicating the ability of the weldment to withstand severe shock loading. In ordinary mechanical testing, properties of the weld material, heat affected zone and parent material have to be determined separately and the overall response of the joint predicted from these properties.

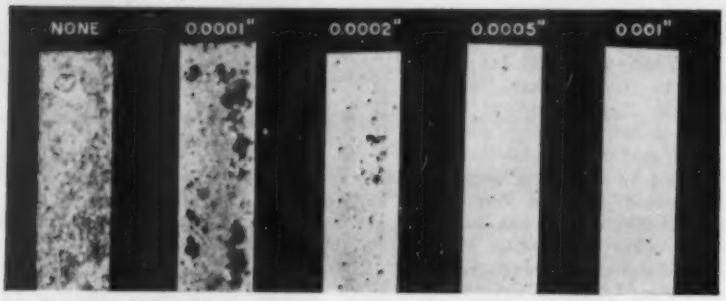
References

A complete bibliography of literature published on industrial uses of explosives will be furnished on request.

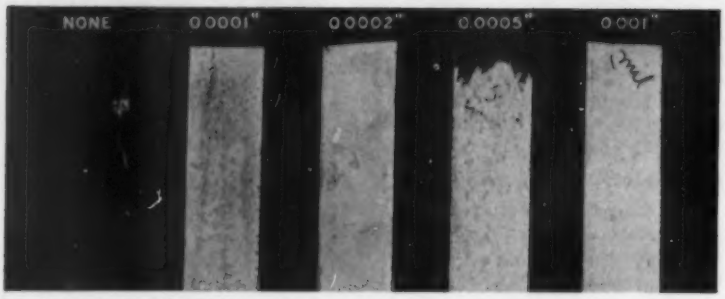
Organizations now doing work in fabricating metals with explosives are: Air Material Command, Wright-Patterson Air Force Base; Convair, Div. of General Dynamics Corp.; Lockheed Aircraft Corp.; Moore Co.; National Northern Corp., Div. of American Potash & Chemical Corp.; and Olin-Mathieson Chemical Corp.

How aluminum-plated magnesium resists . . .
(AZ31B, ½-in. wide strips, coating thicknesses as indicated)

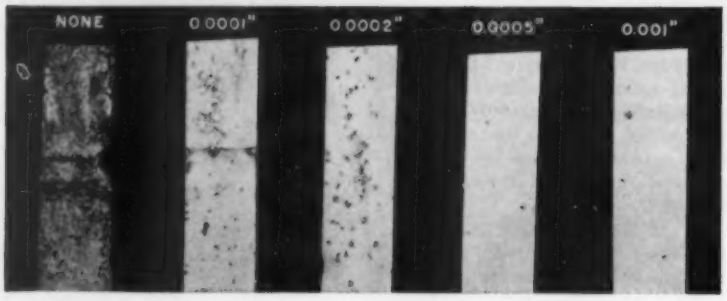
50 hr salt spray



10 days high humidity



30 days in cooling tower



New High-Purity Aluminum Coatings

For: corrosion resistance
Electrical insulation

by J. J. Utz and S. Kritzer, *Missile Division Laboratory, North American Aviation, Inc.*

■ Despite their excellent combination of properties, pure aluminum electrodeposited coatings have not generally been available. However, an efficient method of producing such coatings has recently been developed. The method, a comparatively simple electrochemical process that runs at ordinary temperatures, is expected to be quite suitable for large scale operations.

Adherent coatings have been produced on steel, copper, magnesium, silver, gold, iron, zinc and nickel. It is believed that they can also be successfully applied to titanium, molybdenum, rhenium and corrosion resistant steels.

How they can be used

1. For corrosion resistance

The high purity aluminum coating is valuable in improving the corrosion resistance of irregularly shaped objects that are forged, machined, or otherwise fabricated from sensitive alloys. Electrolytic aluminum appears to provide sacrificial galvanic corrosion protection to magnesium and all metals below it in the electromotive series. Corrosion protection is further enhanced by the good throwing power of the bath in recessed areas.

Electrolytic aluminum is being considered as a replacement for cadmium to protect steel surfaces against corrosion. A process has been developed to plate aluminum directly on steel with excellent adhesion. The key step in the process consists of activating the steel in a 50:50 (by volume) mixture of dry ether and a Du Pont chromium complex called Quillon. Some test results:

- A 4130 steel panel plated with 1 mil of electrolytic aluminum was exposed to the aerated spray of a cooling tower. After 11 months the aluminum coating had corroded badly, but the steel substrate was undamaged.
- Steel aircraft bolts plated with ¼ mil of aluminum were subjected to 75 hr of standard salt spray testing before any corrosion of the steel was noted. However, humidity tests have given inconclusive results and further tests are required to fully evaluate corrosion protection.

High purity aluminum has been studied as a corrosion protection system for magnesium. Although the electromotive series indicates

that magnesium is anodic to aluminum, there is strong evidence that magnesium will not be preferentially corroded by ultra-high-purity aluminum. Successful corrosion tests have been made with electrolytic aluminum on wrought FS-1 magnesium.

One result: less weight—Because of their resistance to certain corrosive agents, aluminum coatings can be used to protect parts that are light in weight but have poor corrosion resistance. In one North American missile application, engineers calculated that by substituting magnesium for aluminum in booster liquid oxygen and alcohol pumps they could reduce weight by nearly one-third. Although magnesium has poor surface properties for this application, the designers reasoned that lightweight magnesium could attain the required corrosion and abrasion resistance if it were coated with electrolytic aluminum.

2. For electrical insulation

Electrical conductors that must operate at high temperatures can be insulated with a layer of anodized electrolytic aluminum. A similar insulated layer has been proposed for use on the core laminations of miniature motors, generators and transformers designed for high temperature use. If this system proves practical, then only every other lamination would have to be coated. A desirable characteristic of the anodized aluminum insulation is that an arc between coils or layers does not leave a low resistance carbon track between the conductors.

Anodized electroplated aluminum has been used experimentally as a high temperature electrical insulation on copper wire. In the as-plated condition the electrolytic aluminum appears as a crystalline deposit. A superior anodic film is obtained if the coating is converted to a wrought surface before anodizing. Drawing the wire through a die refines the grain structure and gives the surface a smooth, bright finish which, when anodized, becomes an insulating coating.

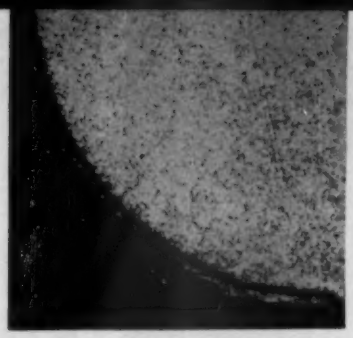
Although an electrochemical device has been built that will continuously plate the high purity aluminum on copper wire, good adhesion is not obtained. The reason appears to be the slow rate the wire has to travel to produce a 1-mil deposit, which results in a comparatively long time between cleaning steps. Tests have shown that good adhesion can be obtained only if the time between steps in cleaning the copper is short. Thus, it is expected that good adhesion can be obtained by using a larger aluminum plating cell which would allow more wire to be immersed in the bath at one time and decrease the time between processing steps.

3. To raise emissivity

An anodized electrolytic coating on steel provides 95 to 98% of the thermal emissivity associated with a theoretical black body. Such a highly emissive surface may be beneficial for compact electronic components that operate at high temperatures.

Electroforming Also

In addition to providing high purity aluminum coatings, the new electrodeposition process can be used for electroforming. It is expected to be particularly valuable for forming lightweight structural and electronic components requiring precise curvatures or interior dimensions for proper performance. Two applications being considered are gyro support gimbals and high frequency waveguide sections.



***Insulated wire** is produced by continuously electroplating aluminum on copper wire, then anodizing the aluminum. (60X)*

***Lightweight waveguide** section with precise interior dimensions is made by electroforming aluminum to 0.11-in. thickness.*

How they're applied

Of the bath formulations tested, the most successful is made by dissolving anhydrous aluminum chloride in sodium-dried diethyl ether to a concentration of 3.5 ±0.2 moles per liter. The resultant solution is filtered under an inert atmosphere until clear. The clarified solution is then saturated with lithium hydride and the bath is again filtered as before until free of solids. The bath may be used at once or stored in polyethylene bottles at 50 to 86 F.

The bath may be operated within the following limits:

Current density—1 to 20 asf of cathode area.

Anode-cathode surface ratio—At least 1:1.

Temperature—68 to 86 F (decomposition occurs both above and below these limits).

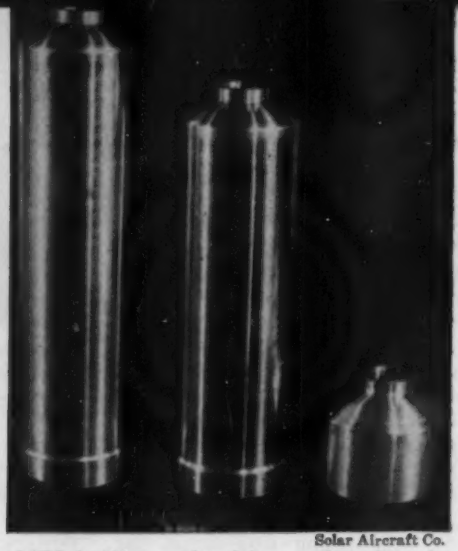
Deposition rate—0.5 mil per hr at 10-asf cathode current density.

The bath has high electrical conductivity. About 1.1 v are required to produce 5 asf on a cathode separated 4 in. from the anode. This level of conductivity is about the same as that of a conventional acid copper bath having similar electrode geometry.

Progressive cathode depolarization begins at the moment plating power is turned on. Cathode depolarization, or the reduction of aluminum to zero valence, determines how well the aluminum will adhere to the base metal. In general, a higher degree of depolarization produces better adhesion. Similarly, a shorter depolarization time to equilibrium also produces better adhesion.

Solar Aircraft Co.

Nacelle structure *has AM350 skin and 17-7PH structural elements for ease of forming in the soft condition.*



Solar Aircraft Co.

JATO bottles *produced from tool steel can be heat treated to 285,000 psi tensile strength.*

Six Precautions in Using High Strength Steels

Certain problems not normally too serious can become very important in steels heat treated to high strength levels. To select the best material, particularly for aircraft, you must be fully aware of these limitations.

by Edward A. Loria, *Metallurgical Development Division, Climax Molybdenum Co.*

1. Transverse ductility drops considerably in steel heat treated to high strength levels. Transverse test data are not extensive and are significant for comparing steels only if the data pertain to the same cross section and take into account the processing steps employed in arriving at that cross section.

Table 1 compares the longitudinal and transverse properties of two steels heat treated to high strengths. Although the ductility is good in the transverse direction, it is significantly lower than in the longitudinal direction.

TABLE 1—LONGITUDINAL VS TRANSVERSE TENSILE PROPERTIES

Steel	Section Size, in.	Test Dir	Yld Str (0.2%), 1000 psi	Ten Str, 1000 psi	Elong, %	Red. of Area	Rockwell Hardness	Impact Str, ft-lb
56[c]	4[b]	Long.	248	311	12	37	C56	—
		Trans.	230	310	3	7	C56	6-12
	4[c]	Long.	245	310	7	23	C56	—
		Trans.	205	—	0-1	—	C56	2-4
422[d]	4	Long.	167	208	15	48	C44	—
		Trans.	156	203	10	19	C44	—
	12	Long.	171	213	13	42	C42	—
		Trans.	165	212	8	14	C42	—

[a]Austenitized 1 hr 1900 F; air cooled; double tempered 2 + 2 hr at 1000 F.
[b]Vacuum melted.
[c]Air melted; transverse specimen had brittle failure.
[d]Austenitized 1900 F; oil quenched; tempered 1 hr at 1050 F.

High Temperature Steels: The Three Groups

Structural steels under consideration for use in high speed aircraft and missiles can be divided into three types: 1) martensitic, 2) semi-austenitic, and 3) austenitic. Each type has certain advantages, but also certain limitations that must be recognized to avoid serious problems. Only rarely will a given steel be optimum in all respects.

The accompanying table lists the compositions of representative steels in each group which are discussed in this article. Some important characteristics of each group.

Martensitic steels

Two of the steels in this group are hot work tool steels. These are not stainless grades and their surfaces require protection. The third is a stainless grade of the 400 series. Compared with the semi-austenitic grades, its advantages are lower coefficient of thermal expansion and higher thermal conductivity. It has two disadvantages:

1. The greater dimensional change occurring in heat treatment than occurs in the austenitic grades.

2. Stress corrosion that becomes severe in material heat treated to high strength levels; some type of coating, such as diffused cadmium-nickel, is required for protection.

Semi-austenitic steels

These grades are supplied in the high temperature annealed (1950 F), stable austenitic condition. To obtain proper response to subzero cooling and tempering, they must be re-solution treated at 1750 F. Even with this treatment some difficulties have been encountered because of nonuniform response to heat treatment. The semi-austenitic grades undergo dimensional changes during heat treatment of the same order of magnitude as the 400 stainless grades. The lower chromium content of 15PH-7Mo and AM355 reduces their corrosion resistance below that of the earlier (17-7 PH and AM350) semi-austenitic grades.

Austenitic steels

The two austenitic steels are precipitation hardenable and can be used at service temperatures above those suitable for the martensitic and semi-austenitic grades. In the hardened condition they have greater ductility than the steels in the other two groups. Corrosion resistance of the two alloys is generally equal to that of type 304; oxidation resistance of A-286 equals that of type 310 up to 1800 F.

COMPOSITION OF STEELS (%)*

Steel	C	Cr	Ni	Mn	Mo	V	Other
MARTENSITIC							
422	0.22	12.0	0.70	0.65	0.95	0.25	W 0.95
218	0.40	5.2	—	0.35	1.40	0.45	Si 0.90
56	0.40	3.25	—	0.50	2.80	0.35	Si 1.00
SEMI-AUSTENITIC							
17-7 PH	0.07	17.0	7.0	—	—	—	Al 1.15
PH 15-7 Mo	0.07	15.0	7.0	0.70	2.50	—	Al 1.35
AM 350	0.08	17.0	4.2	0.60	2.75	—	—
AM 355	0.13	15.5	4.35	0.95	2.75	—	—
AUSTENITIC							
HNM	0.30	18.5	9.5	3.5	—	—	P 0.20
A-286	0.05	15.5	26.0	1.35	1.75	0.30	Al 0.20; Ti 2.0

*422, 218, 56 and HNM are Crucible Steel Co. grades. 17-7 PH and PH 15-7 Mo are Armco Steel Corp. grades. AM 350 and AM 355 are Allegheny-Ludlum Steel Corp. grades. A-286 is available from several sources.

2. Performance of a material under biaxial tension is not predicted by the ordinary tensile test. Hydrostatic tests to destruction of thin-walled pressure vessels (missile tanks and solid propellant engine cases) prove that many materials having tensile strengths above 200,000 psi show brittle fracture at stresses below their uniaxial tension yield strengths. Such results indicate that a steel may be at a higher stress level under biaxial than under uniaxial tension. Even notched tensile tests can be misleading unless the notch is particularly sharp. To avoid premature failure under biaxial stresses, a steel should possess more ductility than is required for service under uniaxial stress.

Tear strength (crack propagation) tests have been used to determine the cracking tendency of a steel. Apparently a good spread between yield strength and tensile strength, accompanied by high elongation, affords greater ductility under biaxial stresses than a higher yield-tensile ratio and low elongation. There are some indications that the yield-tensile ratio should be lower than 0.85; apparently notch sensitivity drops near this value. Fig 1 shows that AM350, as hardened, has the highest tear resistance of the group of steels under discussion.

3. Fatigue strengths of sheet steels can be markedly reduced by surface decarburization. In non-stainless steels, decarburization resulting from sheet rolling operations and final heat treatment can be a serious problem because decarburized steels have lower fatigue strengths than those that have not lost surface carbon. In grades 56 and 218, partially decarburized surfaces reduce tensile properties in gages thinner than 0.040 in. but apparently do not affect tensile properties above that gage. However, fatigue properties are affected. Fig 2 shows the effect of decarburization on the fatigue strength of 218.

Pack rolling is used in the pro-

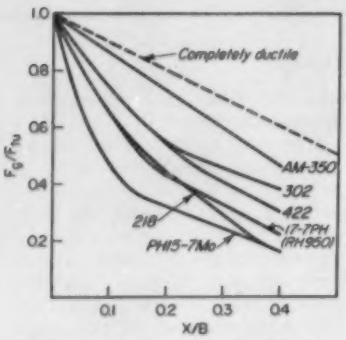


Fig 1—*Crack propagation tests indicate the tear resistance of tensile specimens having center cracks. In this graph:*

X = *crack length at maximum load*
B = *sheet specimen width*
F_g = *maximum gross area stress*
F_{tu} = *tensile ultimate stress*

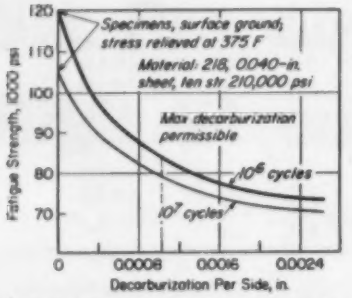

Specimens, surface ground; stress relieved at 375 F
Material: 218, 0.040-in. sheet, ten str 210,000 psi
Max decarburization permissible
10^6 cycles
10^7 cycles
Fatigue Strength, 1000 psi
Decarburization Per Side, in.

Fig 2—*Decarburization reduces fatigue strength of 0.040-in. 218 steel.*

duction of thin sheet from these steels and final dimensions are obtained by grinding. Surprisingly, the grinding marks raise, rather than lower, the fatigue strength, apparently because the many fine notches resulting from grinding neutralize each other. Table 2 is a comparison of the fatigue strengths of decarburized sheet with sheet finished by grinding on a steel heat treated to a high strength.

Airframes are difficult to design for fatigue strength, but such parts can be evaluated for fatigue properties and modified if necessary. Although rupture and creep are the limiting stresses at high temperatures, fatigue strength may be a significant factor at moderate temperatures. At these temperatures fatigue strength may be less than rupture strength

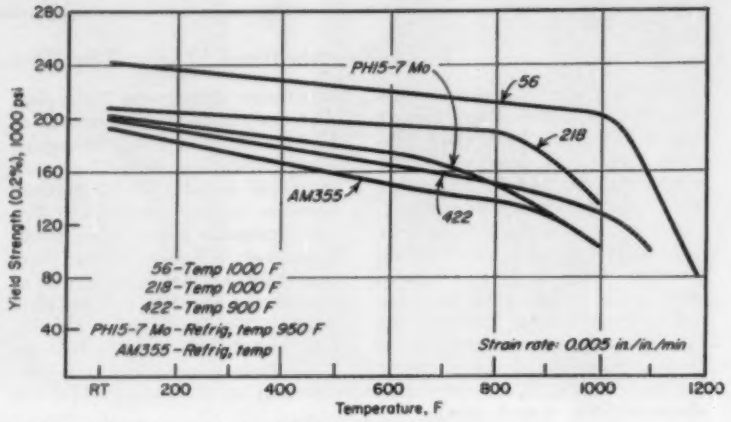


Fig 3—*Yield strength at elevated temperatures.*

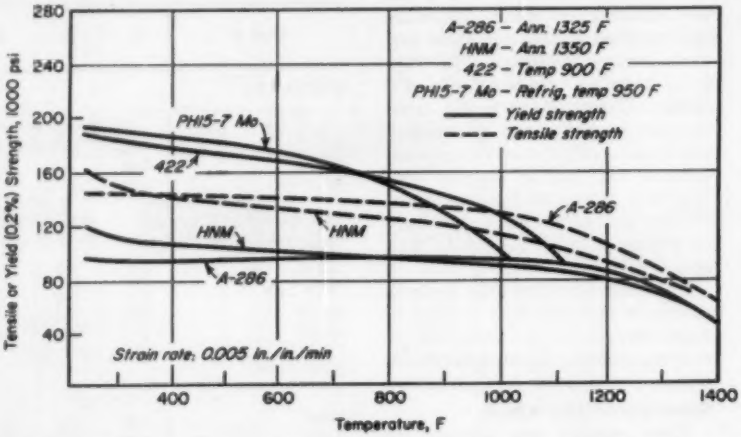


Fig 4—*At temperatures to 800 F, yield strengths of the martensitic and semi-austenitic steels are higher than the ultimate strengths of the austenitic steels. The austenitic steels are superior above this temperature.*

TABLE 2—EFFECT OF DECARBURIZATION ON FATIGUE STRENGTH (218 Sheet*)

Surface ↓	Fatigue Strength, 1000 psi			
	10^4 Cycles	10^5 Cycles	10^6 Cycles	10^7 Cycles
0.005 In. Decarburization Each Side	146	90	74	70
Ground	204	152	123	117

*0.080-in. sheet heat treated to 285,000 psi tensile strength, 6% elongation. Decarburized sheet heat treated in salt bath; ground sheet heat treated in controlled atmosphere.

for equivalent service periods because alloying has less effect in increasing fatigue strength than in increasing rupture strength; in designs permitting 10^8 cycles of stress in less than 1000 hr, fatigue strength is lower than rupture strength over a considerable temperature range.

4. Yield strength, particularly at elevated temperatures, is a more realistic design criterion than the traditional ultimate tensile strength. Yield strengths of a number of steels are given in Fig 3. The non-stainless martensitic steels 56 and 218 are significantly stronger than the austenitic steels throughout the temperature range; the stainless martensitic steel (422) has strength similar to that of PH15-7Mo up

Ryan Aeronautical Co.

***Jet engine rings** utilize A-286, taking advantage of the superior structural strength of the austenitic steels at high temperatures.*

to about 800 F but is stronger above that temperature.

A more striking comparison is made in Fig 4. Yield strengths of 422 and PH15-7Mo are considerably higher than the tensile strengths of stable austenitic steels up to 800 F.

5. At some temperature the metal starts to flow at a significant rate and will break below the yield stress. Above this temperature, which varies with the material, stress-rupture or creep properties are used as the service criteria, and the order of merit of materials may change. As showr in Fig 5, the stress-rupture properties of the martensitic steels 218 and 422 are considerably higher than those of semi-austenitic PH15-7Mo and AM350 and austenitic A-286 at temperatures below 800 F. Above this temperature, the rupture strengths of the martensitic and semi-austenitic steels drop rapidly whereas A-286 retains a larger proportion of its strength. Although not included in the graph, the properties of HNM are similar to those of A-286.

A more precise criterion than rupture strength is the stress required to produce a given strain in a definite time interval. For 0.2% extension in 1000 hr at 1000 F, the stress required would be 44,000 psi for 218 and 83,000 psi for A-286, showing the superiority of the austenitic steel over the martensitic at this temperature. Data of this type simplify the task of evaluating the effect of creep on design and can be presented in the form of isochronous (constant time) stress-strain curves. Such a series of curves is given In Fig 6 for A-286 and 218 sheet. The curves are constructed from creep data by plotting the strain produced by different stresses at constant time. The relationship of isochronous curves to a tensile stress-strain curve is such that the points at which the isochronous curves deviate from the straight line indicate the stress at which creep becomes important in design.

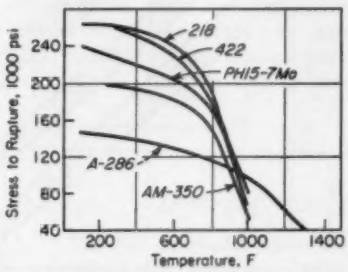


***Fig 5**—Stress-rupture properties of the martensitic and semi-austenitic steels are superior to those of austenitic steels up to 800 F, but drop rapidly at higher temperatures.*

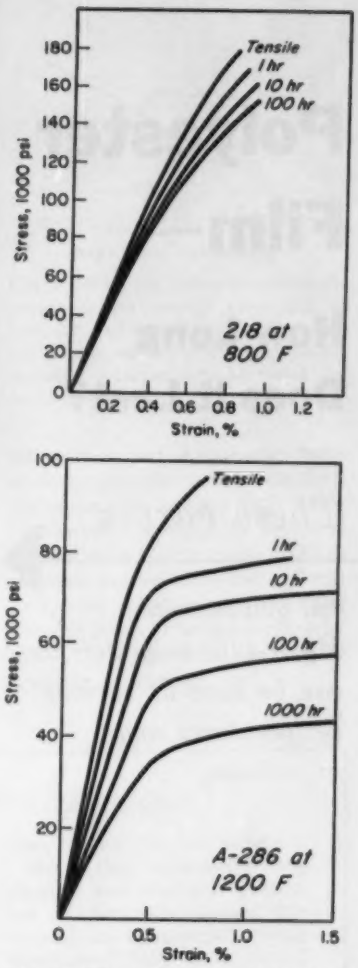


***Fig 6**—The points at which these isochronous curves deviate from a straight line are the stresses at which creep becomes important in design.*

6. The modulus of elasticity at elevated temperatures varies with the method of determination. At room temperature, the modulus is a constant for each alloy system; for ferritic steels, the tensile modulus of elasticity is 30 x 10^6 psi and for stainless steels it is 28 x 10^6 psi. At elevated temperatures, the modulus may differ, depending on whether it was determined by static or dynamic methods. Since the static stress-strain curve is affected by inelastic effects at elevated temperatures, and the dynamic method is not affected, the modulus curve determined by static methods will be lower than that determined by dynamic methods. The higher the temperature, the greater will be the deviation.

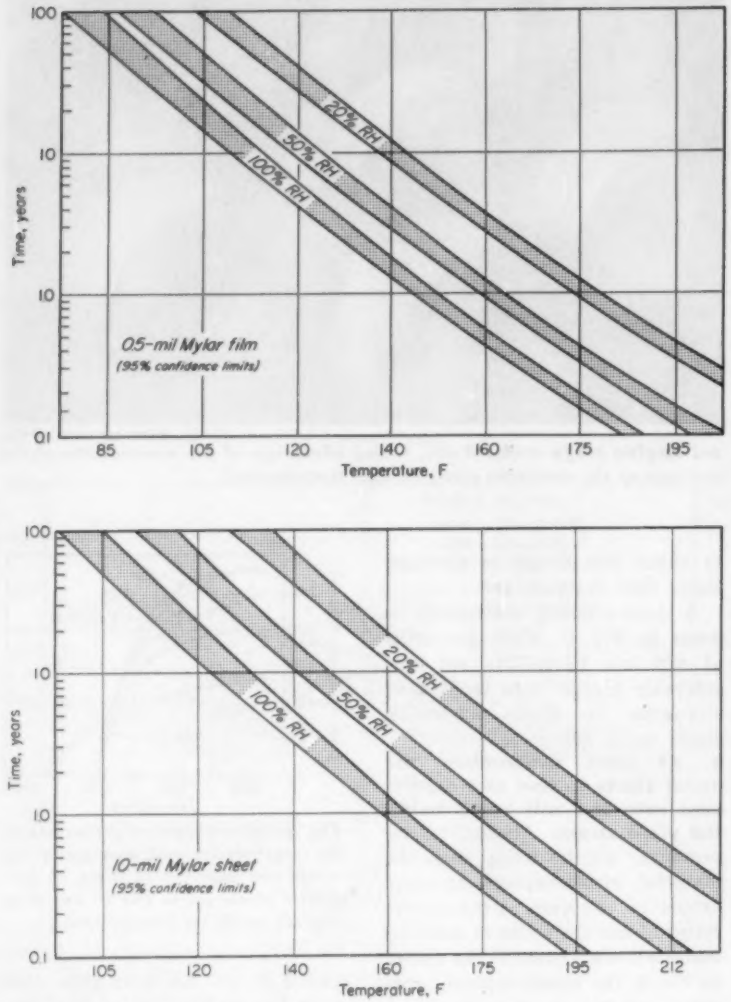
Polyester Film—

How Long Does It Last?

These curves

tell you how long Mylar-type polyester film can be used at various temperatures and humidities.

by W. McMahon, H. A. Birdsall, G. R. Johnson, and C. T. Camilli,
Bell Telephone Laboratories, Inc.



Useful service life *of 10-mil Mylar sheet (bottom) and 0.5-mil Mylar film can be picked off the ordinates by selecting the humidity and temperature conditions expected in service.*

■ Useful service life of polyethylene terephthalate-type polyester film—Du Pont's Mylar—as determined by these curves is defined as the exposure time at any humidity and temperature level which the material will withstand before its tensile strength is reduced to about two-thirds of the initial value. Tensile strength is used as the limiting factor because it was found to be the property most sensitive to degradation. When degradation of the film has reduced tensile strength about one-third, dielectric properties are only slightly affected, although folding endurance is usually negligible.

Mechanical properties

Fig 1 shows the effect of chemical degradation (as expressed by log A/A-X, representing reaction rate) on tensile strength of 0.5-mil polyethylene terephthalate film. The point at which tensile strength drops off sharply is the degradation point selected to define safe service life. At this point, approximately two-thirds of initial tensile strength is retained, or about 14,000 psi in 0.5-mil film and 16,000 psi in 10-mil sheet. Elongation in the 0.5-mil film is reduced from 99% to about 2%; in the 10-mil sheet from 158% to about 6%. Limited data on folding endurance indicate that it is nil at this point.

Dielectric strength

Dielectric breakdown strength, often the most sensitive of electrical properties to degradation, is little changed by exposure to moisture and heat. Data indicate

that exposed film does not lose its dielectric strength until it has degraded to the point where it is brittle and physically weak. The selected values given in the table are averages of 20 samples. In many cases, particularly in air, dielectric strength improves slightly on exposure to heat and some moisture.

Dielectric constant and loss

Values in the table show that change in dielectric constant due to exposure to moisture is relatively insignificant. There may be a slight trend toward lower constants after exposure. Dielectric loss, change in which is also small, seems to increase in those samples heated in dry air and decrease in those heated in moist air. A possible explanation is that moisture may free some loss-contributing impurities which may volatilize during exposure and during drying.

Insulation resistance

Values in the table show the effects of exposure to humidity and heat. Insulation resistance measurements were made on exposed samples after standard ASTM conditioning, at both 1) 75 F and 50% RH, and 2) two days at 95 F and 90% RH. After conditioning at the lower humidity and temperature level, resistance was above the range of the test galvanometer, i.e., greater than 2×10^{13} ohm. After conditioning at the higher temperature and humidity, resistance was decreased substantially. However, when the surfaces of the samples were washed, resistance increased again to that of the unexposed material.

The decrease in resistance on exposure to heat and humidity was found to be caused by the progressive accumulation of particles on the surface during the exposure period. Apparently some of these particles are nonconducting when dry, but are sufficiently hygroscopic or ionic to be quite conductive in high humidity. Other particles proved to be low molecular weight polymer present in the film and brought to the surface by heat. These particles are not all products of degradation.

***Fig 1**—Note the sharp breaks in the curves where tensile strengths of both 0.5 and 10-mil Mylar film drop off. Values on the abscissa represent chemical reaction rate at which degradation occurs.*

ELECTRICAL DEGRADATION

Conditions	Results
Dielectric Str (avg), kv/mil[a]	
Control	11.49
Air, 180 F, 315 days	12.22
Air, 210 F, 67 days	12.51
95% RH, 195 F, 21 days	11.83
Water, 140 F, 126 days	10.08
Water, 210 F, 10 days	10.20
Dielectric Constant (1 kc)[b]	
Control	3.35
Dry, 195 F, 91 days	3.20
Dry, 212 F, 49 days	3.29
75% RH, 195 F, 50 days	3.30
75% RH, 212 F, 49 days	3.30
Loss (tan δ)[b]	
Control	0.00422
Dry, 195 F, 91 days	0.00575
Dry, 212 F, 49 days	0.00489
75% RH, 195 F, 50 days	0.00398
75% RH, 212 F, 49 days	0.00313
Insulation Resistance, ohm[b,c]	
Control	2×10^{12}
Air, 175 F, 245 days	4×10^{8}
Air, 195 F, 105 days	8×10^{7}[d]
75% RH, 175 F, 140 days	6×10^{9}
95% RH, 195 F, 35 days	2×10^{8}[e]

[a]0.5-mil film. [b]10-mil sheet.
[c]Values given are averages obtained after aging under stated conditions followed by conditioning specimens for 2 days at 90% RH and 95 F. After the same aging conditions, but followed by conditioning at 50% RH and 75 F, test results showed insulation resistance to be unchanged, i.e., $> 2 \times 10^{13}$.
[d]Value obtained after washing specimen was $> 2 \times 10^{12}$.
[e]Value obtained after washing specimen was $> 3 \times 10^{11}$.

How the Curves Were Developed

The Bell researchers first determined how hydrolytic degradation, as measured by changes in number average molecular weight, varies with exposure time. From the resulting data they were able to determine the activation energy of hydrolysis and, consequently, the rate at which the reaction proceeds at any chosen temperature. Thus, they established the relationship between a convenient index of degradation and the variables of time, temperature and moisture.

Next, they determined the physical and electrical properties of materials exposed for varying times, temperatures and humidities. They then plotted the relationship between observed changes in molecular weight on the one hand, and physical and electrical properties on the other hand. By correlating these data they were able to obtain the accompanying design curves.

***Telephone** step-by-step switching bank, several million of which are now in operation throughout the country, uses polyethylene terephthalate insulation. Long life is a critical requirement.*

Sikorsky Aircraft Div., United Aircraft Corp.

Rotor blades *for helicopters are adhesive-bonded.*

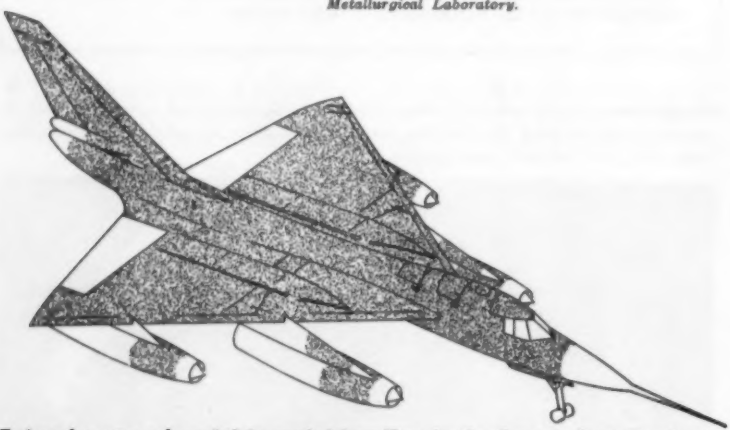
Here is an up-to-date report on . . .

Adhesive Bonding of Titanium

Available adhesives
Surface treatments
Design factors

by H. E. Pattee, G. E. Faulkner and P. J. Rieppel,
Defense Metals Information Center, Battelle Memorial Institute*

*Previously the *Titanium Metallurgical Laboratory.*



Extensive use of metal-to-metal bonding *in the Convair B-58 Hustler is indicated by shaded areas.* Convair

■ As aircraft speeds, and hence operating temperatures, continue to increase, the need for honeycomb structures that remain structurally sound at temperatures above 500 F will become greater. It is this need that has stimulated the development of adhesive-bonded titanium structures.

Two of the many problems that have tended to slow the development of adhesive-bonded titanium structures are: 1) the unavailability of adhesives that can be used at elevated temperatures for long periods of time, and 2) the unavailability of suitable surface treatments to prepare titanium for bonding. In addition, the use of titanium core materials will necessitate some changes in manufacturing techniques and tools used in adhesive bonding.

Adhesive blends are best . . . but they do not solve all problems. The adhesive blends are combinations of thermoplastic, thermosetting and elastomeric adhesives which are formulated to obtain

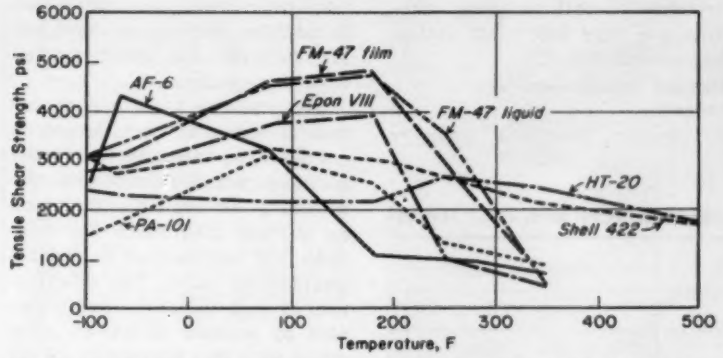


Fig 1—*Tensile-shear strength vs temperature for 2024-T3 Alclad aluminum joints bonded with different adhesives.* (Merriam and Goplen)

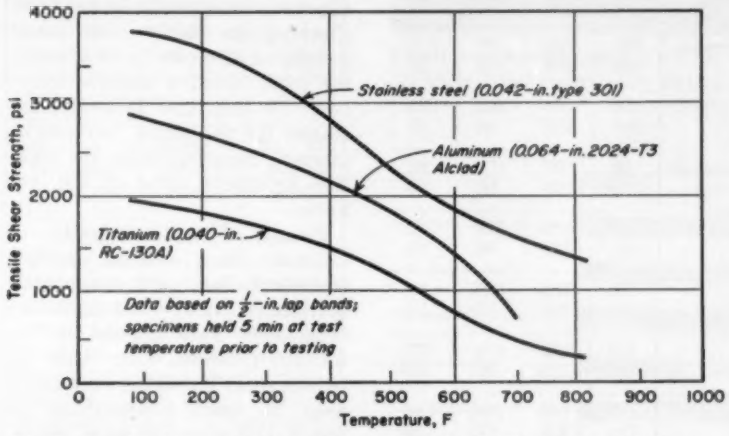

Tensile Shear Strength, psi
Temperature, F
Stainless steel (0.042-in. type 301)
Aluminum (0.064-in. 2024-T3 Alclad)
Titanium (0.040-in. RC-130A)
Data based on ½-in. lap bonds; specimens held 5 min at test temperature prior to testing

Fig 2—*Tensile-shear strength vs temperature for Shell 422-607 adhesive.* (Horton et al)

the optimum characteristics of each type. The more important adhesive blends are listed in an accompanying box. The most promising of the presently available adhesives are modified phenolic-epoxy resins. Much effort, however, is being exerted to develop high temperature ceramic, organic and semi-organic adhesives.

The high temperature characteristics of commercial adhesives are of particular interest to those considering titanium bonding. Fig 1 gives shear strength-vs-temperature data on several adhesives. The data are based on the performance of a ½-in. lap joint in 0.064-in. thick 2024-T3 aluminum alloy. (Since the joints fail at strengths below those of either aluminum or titanium metal, the data offer a good idea of the kind of strengths obtainable with the different adhesives. Of course, some differences will result with titanium.) Similar data derived from tests of ½-in. lap joints with stainless steel, aluminum and titanium alloys are given in Fig 2 for an epoxide-phenolic adhesive.

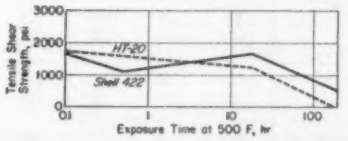


Fig 3—*Tensile-shear strength at 500 F vs exposure time for 2024-T3 Alclad aluminum joints.* (Merriam and Goplen)

Epoxide-phenolic and modified phenolic adhesives are considerably stronger at elevated temperatures than other adhesives and are the types being considered

Metal-to-Metal Adhesive Bonding

Advantages

1. Uniformly distributed load.
2. Reduced weight of structure.
3. High strength-weight and rigidity-weight ratios.
4. Smooth, aerodynamic surfaces.
5. Leakproof joints.
6. Added insulation.
7. Easy handling of dissimilar metals.

Disadvantages

1. Lack of adhesives suitable for prolonged high temperature service.
2. Short shelf life.
3. Low impact and peel resistance.
4. Poor aging, weathering and salt spray resistance.
5. Lack of nondestructive testing procedures.
6. Unfamiliarity with variables.
7. Need for special surface preparation.

Some Commercial Adhesive Blends

Phenolic-Acetal
- Redux (Rohm & Haas Co.)
- FM-47 (Bloomingdale Rubber Co.)
- 55-10-5 (Chrysler Corp.)

Phenolic-nylon
- Cycleweld C-6 (Chrysler Corp.)

Phenolic-rubber
- PA-101 (Bloomingdale Rubber Co.)
- 11575-HD (Flintkote Co.)
- Plastilock 601, 604, 608 (B. F. Goodrich Co.)
- AF-31, EC-1245, Scotchweld 585 (Minnesota Mining & Mfg. Co.)
- Metlbond 4021, M3-C (Narmco, Inc.)

Epoxide-phenolic
- Shell 422-J (Shell Development Co.)
- BMS 5-17 (Boeing Airplane Co.)
- Metlbond 302 (Narmco, Inc.)
- Aerobond 422 (Adhesive Engineering Co.)

Modified phenolic
- HT-20 (Bloomingdale Rubber Co.)

most seriously for bonding titanium. Unfortunately, the effects of prolonged exposures at high temperatures on these adhesives are not very satisfactory. As shown in Fig 3, the tensile-shear strengths of both of these adhesives are very low after 100-hr exposure at 500 F.

Surface treatments are necessary . . .

and several promising preparations have already been developed. In addition, techniques developed for stainless are being applied with some success.

The available literature on surface treatments for titanium is not nearly as extensive as it is for stainless steel. Results of a lengthy screening of available literature on surface treatments for titanium are summarized in the accompanying table. The effectiveness of each treatment was evaluated by bonding Ti-6Al-4V alloy strips with two adhesives: AF-31 (a phenolic-nitrile rubber adhesive) and Aerobond 422 (a phenolic-epoxy adhesive). As has been observed previously with other metals, an acid etch is, in general, the most effective surface treatment for titanium. However, the reason for the slight increase in strength resulting from the alkaline detergent rinse is not yet known.

Results of an investigation to evaluate and develop surface treatments for titanium are summarized in Fig 4. Various surface treatments were applied to Ti-6Al-4V titanium alloy and the tensile shear strengths were measured at room temperature, at 500 F, and after 200 hr at 500 F.

The vacuum vapor-plated aluminum, the sprayed aluminum, and the anodic coatings gave the most promising results. However, more recent information indicates that the vacuum vapor-plated gold surface treatment is being specified for bonding titanium faces to stainless steel honeycomb core materials. Also, the anodic treatments were found to give inconsistent results and further research is being conducted.

Design changes will be necessary . . .

when use is made of titanium core materials. In the meantime, titanium facings bonded to stainless steel honeycomb core materials will probably be the most frequently used structures in the immediate future. The same basic manufacturing techniques and tools can be used as are now being used for adhesive bonding of aluminum.

EFFECT OF SURFACE TREATMENTS ON LAP SHEAR STRENGTH OF Ti-6Al-4V JOINTS•

Temperature →	Average Lap Shear Strength, psi			
	−67 F	Room	350 F	600 F
Anodized in 15% Sulfuric Acid	2580 3460	1705 3410	2070 865	1260 275
Anodized in 15% Sulfuric Acid, 2% Chromium Trioxide Added	2770 3225	2060 2740	2170 635	1145 345
Etched in Concentrated Sulfuric Acid-Sodium Dichromate Solution	2205 2960	1585 3250	1595 1155	1175 200
Etched in 10% Hydrofluoric Acid Solution	2070 3040	1795 3575	1800 990	1085 200
Etched in 10% Hydrofluoric Acid Solution and in Dilute Chromic Acid	1840 2790	1845 2455	2220 570	945 290
Anodized in 15% Phosphoric Acid	1095 1575	1155 2295	1350 660	735 305
Etched Anodically in a Buffered Fluoride Solution	970 1845	1155 2505	1355 700	760 315
Anodized in 5% Sodium Hydroxide Solution	1670 910	1365 2225	2340 850	1030 275
Anodized in 5% Formic Acid Solution	1775 3285	1590 3030	2150 815	1385 350
Etched in Borate-Fluoride Solution	1640 1890	1130 2675	1460 930	635 325
Etched in Phosphate-Fluoride Solution	1735 1660	1405 2030	1890 900	915 215
Etched in Nitric-Hydrofluoric Acid Solution	1535 3740	1365 3895	1310 780	655 210
Etched in Solution of Hydrochloric, Phosphoric and Hydrofluoric Acids	1585 2870	1465 2560	1435 540	630 210
Etched in Hot Sulfuric Acid Solution	2330 4355	2235 3155	2195 630	900 195
Etched in Oxalic-Sulfuric Acid Solution	2040 3050	1705 2975	1785 660	915 300
Cleaned with Alkaline Detergent-Sodium Metasilicate Solution	2295 4230	2025 3350	2165 900	1210 290
Etched in Hydrofluoric-Nitric Acid Solution, Cleaned in Alkaline Detergent-Sodium Metasilicate Solution	2600 4190	2025 3430	2415 880	1025 210
Etched in Hot Sulfuric Acid Solution, Cleaned in Alkaline Detergent-Sodium Metasilicate Solution	2640 4230	2570 3550	2685 935	1490 320
Same as Above Except in Heat Treated and Aged Condition	2550 1440	2595 3675	2425 1070	1440 300

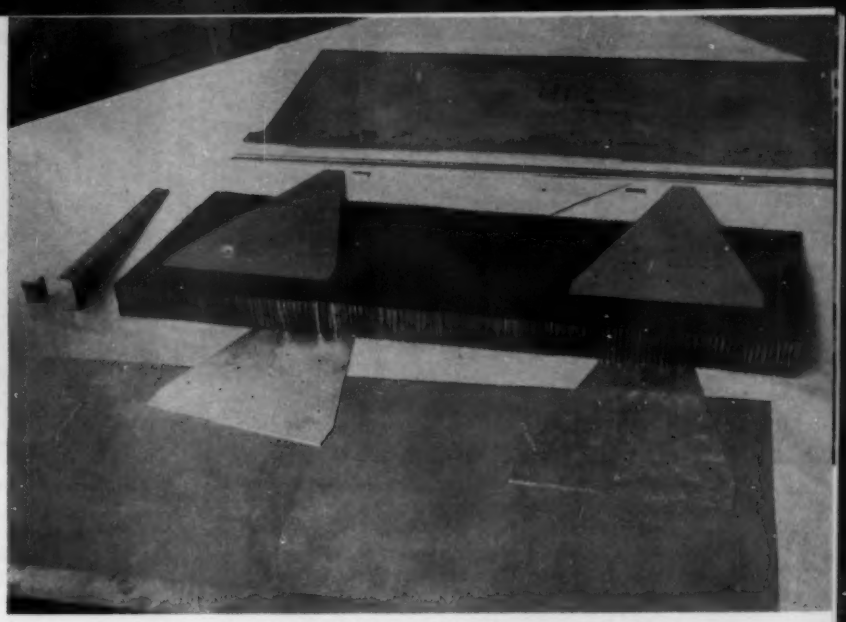
•Annealed condition except as indicated. The two sets of values for each treatment correspond to two separate adhesives: HP 422 and AF-31, respectively.
Source: *Johnson et al.*

Testing of Bonds

The quality of joints and structures made with titanium alone or in combination with stainless steel may be controlled by the same procedures already developed for aluminum, i.e., strict quality control of the adhesive, the surface treatment and the bonding procedures. Impact, shear and other tests may be used to evaluate the bonded joints.

Unfortunately, there is no nondestructive testing procedure for adhesive-bonded joints and structures which is satisfactory in all respects. The ideal nondestructive test would detect unbonded areas, differentiate between poorly bonded and soundly bonded joints, permit rapid inspection of large areas, be adaptable to differently shaped parts, and be simple in operation.

Several research programs are currently underway to develop effective nondestructive testing procedures. Three different approaches indicate that there is: 1) a relationship between the adhesive bond and its thermal conductivity (for a technique based on bond conductivity, see M/DE, Dec '58, p 142); 2) a correlation between bond strength and changes in electrical resistance, capacitance, power factor and other electrical qualities; and 3) a relationship between bond quality and ultrasonic energy absorption. Of these approaches, ultrasonic testing seems to hold the most promise.



***Panel assemblies** using titanium skins and titanium core honeycomb are presently being evaluated by Boeing Airplane Co. The parts shown here will be given a gold vapor coating before adhesive bonding.*

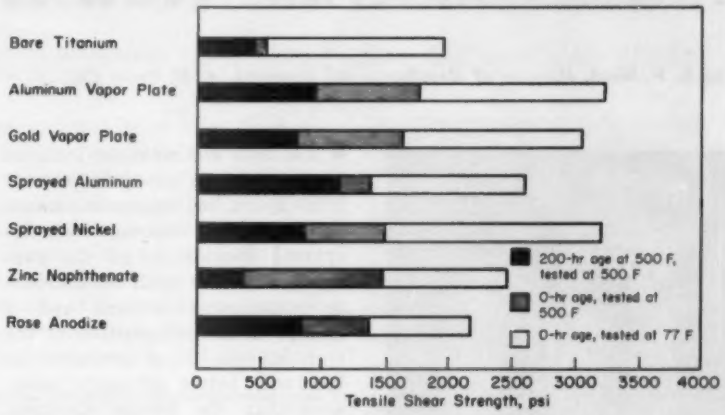


***Fig 4**—Tensile-shear strength vs titanium surface preparations. (Horton et al)*

When titanium core materials are used, the following changes will be necessary as a result of the difference in physical properties of titanium and aluminum:

1. Higher bonding pressures will be necessary because titanium has greater stiffness than aluminum.

2. Provisions for heating the upper as well as the lower facings in sandwich structures will have to be made or panel warping will occur as a result of titanium's lower thermal conductivity.

3. Closer manufacturing tolerances may be necessary because conventional trimming methods generate too much heat. Contour tolerances will also have to be more rigid because the titanium panels will be stiffer than those made of aluminum.

Selected references

Many references were consulted. Here is a selected group:

Arnold, J. S., "Development of Nondestructive Tests for Structural Adhesive Bond," WADC-TR 54-231, Oct '54.

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Bowels, L. T., Jr., "Nondestructive Inspection of Adhesive Bonded Sheet Metal," 21 monthly reports to USAF under Contract AF-33(600)-17822, July '52-Mar '54.

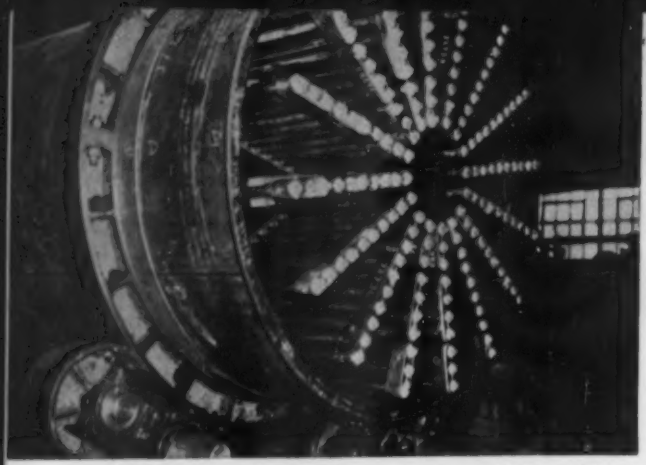
Campbell, G. W., "Process Requirements for the Structural Bonding of Titanium Assemblies," Boeing Airplane Co., Rpt. D-2-1031 to USAF under Contract AF 33(600)-31802, Nov '56.

Horton, R., Cowan, R., et al, "The Development of Structural Bonding Systems and Bonded Sandwich Construction," Boeing Airplane Co., Rpt. D2-1359, Nov '56.

Johnson, W. E., Horrigan, J. R., Sunafrank, W. O. and Hooker, J. R., "Titanium Sandwich Panel Research and Development." Second Quarterly Progress Report to USAF under Contract AF 33(600)-34392, July 1, '57-Sept 30, '57.

Merriman, H. R., and Goplen, H., "Research on Structural Adhesive Properties Over a Wide Temperature Range," Symposium on Structural Adhesives and Sandwich Construction, Dayton, Ohio, June 12-13, '57.

Spriggs, R. M., Lefort, H. G., and Bennett, D. G., "Research on Elevated Temperature Resistant Ceramic Structural Alloys," WADC-TR 54-491, Sept '56.



***Crystallizer** uses cold drawn 4-D wrought iron tubing. Service reports prove wrought iron heat exchanger and condenser tubing to be more durable than many expensive alloys. Wrought iron is unaffected by refrigerating gases such as ammonia, carbon dioxide and Freon.*

***Outdoor skating rink** uses 4-D wrought iron pipe to handle the brine solution used as a refrigerant. Wrought iron is used in more than three-fourths of the nation's permanent ice skating rinks. Piping replacement is quite costly in such rinks, since the entire concrete slab must be torn up and relaid.*

In applications like these New Wrought Iron

by E. P. Best, *Director of Metallurgy and Research, A. M. Byers Co.*

***Nuclear shielding** used in conjunction with instrumentation on a reactor consists of 4-D wrought iron wedges. The metal has low residual and low total metalloid content, especially with respect to manganese and carbon which are excited in a radioactive environment. Thus wrought iron can be used for shielding without distorting radiation measurement.*

■ The new 4-D wrought iron, an improved grade introduced recently by Byers, has become the standard grade of this material. Increased deoxidation of the base metal, together with an increase in phosphorus content and a change in the composition of the iron silicate, have produced an iron with better corrosion resistance than the former standard.

Corrosion properties

The corrosion properties of wrought iron are enhanced by the presence of silicate. Because the silicate is highly resistant to attack, it serves as a barrier to pitting and disperses the corrosive action evenly over adjacent areas. The silicate inclusions also act as a bond for the corrosion products that are formed; as a result a film of corrosion products protects the underlying metal from further attack.

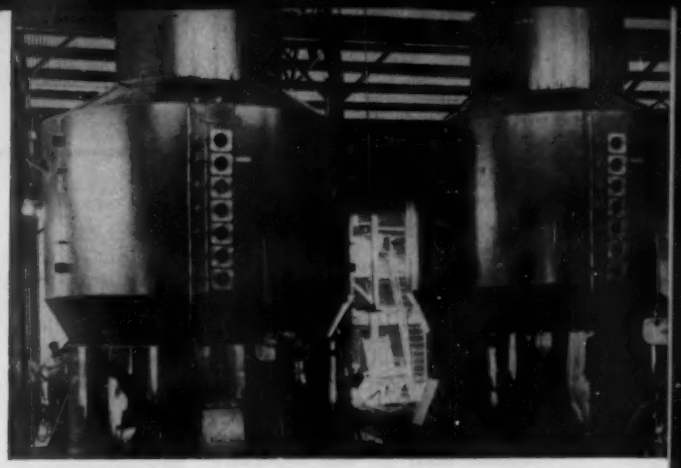
The 4-D grade has characteristics similar to those of the former standard grade, but the changes in composition plus greater uniformity increase its resistance to corrosion. As indicated in Fig 1 and Table 1, 4-D wrought iron shows a marked improvement in resistance to corrosive industrial conditions; based on these tests, 4-D wrought iron has at least 25% greater corrosion resistance than the former grade.

Wrought iron shows its greatest advantage over carbon steels in heat transfer equipment handling brines, industrial cooling waters and industrial flue gases. It is unaffected by refrigerating gases such as ammonia, carbon dioxide and Freon. Fig 2 and Table 1 compare the corrosion resistance of 4-D wrought iron with steel under various service conditions. The greater service life of 4-D is clearly evident.

Increased service life is also evident in the following reports on two specific industrial applications:

• A double-tube ammonia condenser in an ice plant had steel tubes. The cooling medium used on this condenser is a mild brine solution, containing 76 ppm of sodium chloride, at a temperature of 17 F. The steel tubes failed after 2 years and were replaced by wrought iron tubes which are still in excellent condition after 18 years.

Process and oil blending tanks *use wrought iron heating coils extensively. Steam in these coils condenses; 4-D's ability to form its own protective coating of adherent corrosion products prevents the deep pitting and penetration so characteristic of steam condensate corrosion.*



Calandrias and vacuum pans *constructed of 4-D wrought iron are used in sugar refineries. Wrought iron is used to combat two factors: the abrasive action of sugar crystals rushing through the tubes, and the corrosive action of steam in the calandria drums.*

Has Better Corrosion Resistance

—about 25% better than the previous grade.

• Vaporizers for the production of butane and propane gas handle petroleum under pressure at ambient temperatures (10 F min); petroleum is vaporized by passing steam at 10 psi and 265 F through tubes inserted in the jacket. The unit operates continuously. In this application mild steel tubes were destroyed in 3 to 6 months and stainless steel tubes in 6 to 9 months. Wrought iron tubes are serviceable for at least 2 years.

Composition and mechanical properties

Structurally, 4-D wrought iron, like the former standard grade, consists of a physical mixture of two constitutents. The significance of this structure is discussed in

TABLE 1—COMPARATIVE CORROSION RESISTANCE

Service Condition ↓	Effects of Exposure		
	4-D Wrought Iron	Standard Wrought Iron	Steel
Industrial Atmosphere, 17 yr	Loss 540 gm/sq ft	Loss 655 gm/sq ft	—
Aerated Salt Water, 5 wks	Loss 146 mg/sq in.	Loss 170 mg/sq in.	Loss 226 mg/sq in.
Salt Water (Gulf of Mexico), 17 yr	Loss 4 mils/yr; plate still in excellent condn	—	Loss 30 mils/yr; plate badly pitted, perforated
Brine Piping	[a]	No failure in 23 yr (still in service)	Complete failure in 7 yr
Steam Condensate Return Line	[a]	No failure in 10 yr (still in service)	Complete failure in 2 yr
Downspout	[a]	No failure in 29 yr (still in service)	Complete failure in 18 yr

[a] At least 25% greater corrosion resistance than standard wrought iron based on long and short-term tests.

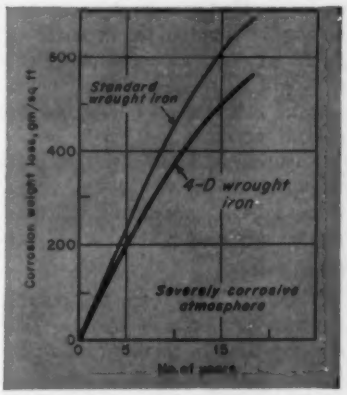
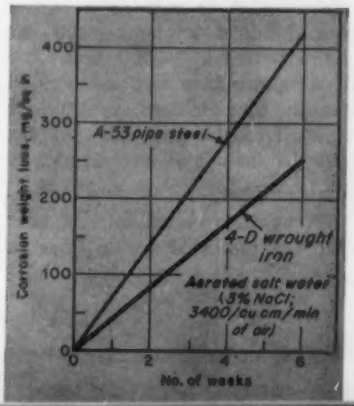


***Fig 1**—Comparative resistance of two wrought irons to an industrial atmosphere, based on 18-year exposure.*

***Fig 2**—Comparative resistance of wrought iron and steel to aerated salt water; conditions simulating the splash zone at mean high tide.*



an adjacent box. The compositions given in Table 2 show that the material consists of commercially pure iron mixed with iron silicate.

During production, the iron silicate is distributed in a fibrous pattern throughout the metal. As a result, wrought iron has definite directional properties with respect to ductility. Elongation of the material is much better in the longitudinal than in the transverse direction.

In general, tensile and yield strengths are practically the same as those of low carbon steel, although wrought iron has a lower density because of the silicate content. Typical properties are shown in Table 3.

Forms and sizes available

The new wrought iron is available both as pipe and in various flat products.

The pipe is available in butt or lap welded standard and extra strong in nominal sizes from ¼ to 12 in., and in a complete line of welding fittings for these sizes. Larger sizes can be obtained on special order.

Sheared plate ranges from 3/16 to 2 in. thick. Other flat rolled forms: bars, rods, ovals, squares, angles and channels.

Fabrication

Wrought iron can be readily formed hot or cold by the procedures used in forming mild carbon steel. Forging requires use of higher temperatures than those used for mild steel, but the low carbon content of the wrought iron minimizes its tendency to burn.

Machinability and threading properties are excellent. Wrought iron has a machinability rating of about 50 based on AISI B1112 steel, which is rated 100 and is the standard of comparison for ferrous metals.

Wrought iron can be welded readily by hammer, oxyacetylene and all of the arc methods; the silicate inclusions act as fluxes.

Applications

Wrought iron piping is used for hot and cold water lines in plumbing systems, steam supply and return lines, condenser water lines, salt water piping, radiant heating, fuel oil lines, oil and gas casing, and line pipe. Cold drawn tubing is used for condensers and unfired heat exchangers and other related heat transfer applications. Many manufacturers of steam traps have standardized on wrought iron pipe and nipples to meet the corrosive conditions caused by noncondensable gases.

In the process industries, tubing is used in handling caustic soda solutions, concentrated sulfuric acid, dry chlorine and ammonia. In sewage plants, 4-D iron is used for digester coils, raw sewage lines, sludge lines, sludge tanks and weir plates.

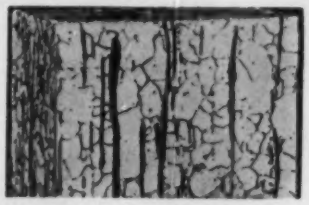
Many major railroads use 4-D wrought iron for air brake piping in both freight and passenger service because of its resistance to vibration and fatigue stresses. It is the standard material specified by the American Assn. of Railroads for passenger car air brake piping.

Other uses include railings, manhole ladder steps, gratings, stacks, coal handling equipment, ducts and breechings. The iron is also finding various applications in nuclear process equipment (see photo, p 100).

Structure of Wrought Iron

The new 4-D wrought iron differs from other ferrous metals because it contains a fine dispersion of very thin silicate inclusions throughout its structure. These inclusions are independent of the grain structure of the iron base. The threads of silicate, which are present in a concentration of approximately 250,000 per cross-sectional sq in., interrupt the granular pattern of the metal, providing a fibrous pattern. The refining and rolling of 4-D wrought iron assures a complete and uniform distribution of the silicate content throughout the metal. This distribution is important because it is the silicate component which gives the material its corrosion resistance.

Presence of the entrained iron silicate also gives the wrought iron a surface that is microscopically rougher than the surface of other ferrous materials. This surface provides excellent "teeth" or anchorage for paints and enables wrought iron to take up to 50% heavier coatings of galvanizing than steel does.



***Distribution** of iron silicate fibers in a pure iron base is the distinguishing characteristic of 4-D wrought iron.*

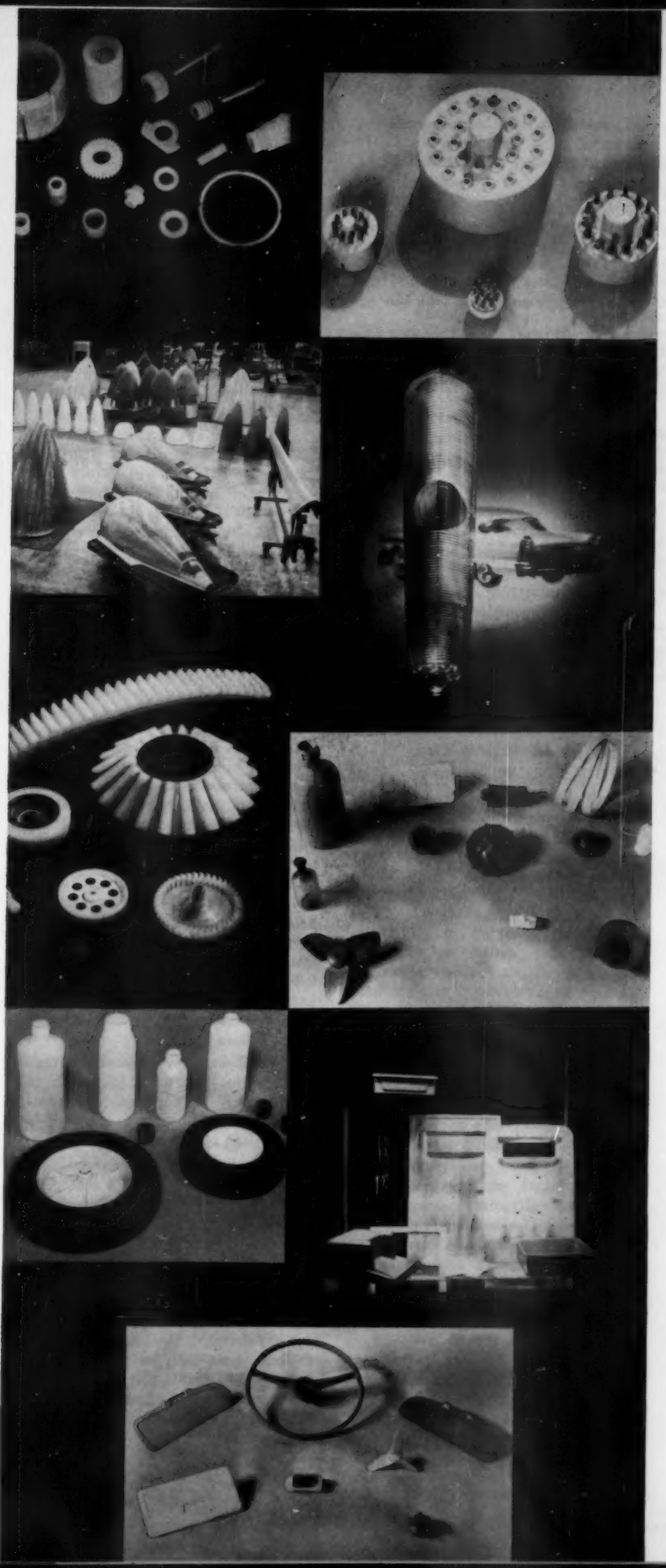
TABLE 2—COMPOSITION OF 4-D WROUGHT IRON

Element	Constituents of . . .		Comb. Comp, %
	Base Metal, %	Iron Silicate, %	
Carbon	0.02	—	0.02
Manganese	0.05	0.01	0.06
Phosphorus	0.10	0.02	0.12
Sulfur	0.02	—	0.02
Silicon	0.01	0.11	0.12
Silicate	—	—	2.50

TABLE 3—PROPERTIES OF 4-D WROUGHT IRON

PHYSICAL PROPERTIES	
Density, lb/cu in.	0.278
Melting Point, F	2750
Ther Cond (64 F), Btu/hr/sq ft/°F/ft	34.5
Coef of Ther Exp (68-200 F), per °F	7.4 x 10^{-6}
Specific Heat, Btu/lb/°F	0.11
Mod of Elast in Tension, psi	29.5 x 10^{6}
Mod of Elast in Shear, psi	11.8 x 10^{6}
Poisson's Ratio	0.30
MECHANICAL PROPERTIES*	
Tensile Strength (min), 1000 psi	48
Yield Strength (min), 1000 psi	27
Elongation (8 in.), %	14
Hardness (Brinell)	97-105
Impact Strength (Charpy), ft-lb	24-28
Shear Strength, 1000 psi	46

*Longitudinal.



Materials
in Design Engineering

Manual No. 156
February 1959

If you're not very familiar with the 19 major types of plastics available today, we suggest you read this . . .

Engineer's Guide to Plastics

A concise outline of a complex field, this manual will tell you what kinds of materials you can buy, their outstanding properties, and where they're used—in short, a useful introduction to plastics as engineering materials.

by Malcolm W. Riley,
Associate Editor,
Materials in Design Engineering

■ There is a confusing number of plastics engineering materials available today. The 19 general types discussed here are the most commonly used. Because of space limitations some plastics have been ommitted, e.g., cold-molded organics, furanes and such natural resins as zein and casein. Also, in some cases, more space is given to the newer materials than to some of the more widely used, better known materials. The amount of space devoted to each material should not be taken as indicative of the volume of usage.

The article does give a broad picture of the important plastics engineering materials, the outstanding properties by which they are characterized, the forms in which they are produced, and typical end-uses to which they are put. The table on page 107 summarizes the attributes of the materials in brief.

The discussion here is primarily in terms of the materials as "plastics," i.e., moldings, castings, extrusions, formable sheet, laminates, etc. Little mention is made of the use of the resins in the form of coatings, adhesives, film or fiber.

Classification

Plastics can be broadly classified as thermoplastic or thermosetting. Common forming techniques for each type are outlined in the box on page 114.

Thermoplastic resins consist of long molecules, each of which may have side chains or groups which are not attached to other molecules (i.e., not crosslinked). Thus, they can be repeatedly softened and hardened by heating and cooling. Usually thermoplastic resins are purchased as a granular polymer. Heat softens the material so that it can be formed; subsequent cooling hardens it in the final desired shape. No chemical change takes place during forming.

In thermosetting resins reactive portions of the molecules may form crosslinks between the long molecules during polymerization; and thus, once "polymerized" or "cured," the material cannot be softened by heating. Thermosets are usually purchased as a liquid monomer-polymer mixture or as a partially polymerized molding compound. In this uncured condition, they can be formed to the finished shape with or without pressure and polymerized with chemicals or heat.

This manual emphasizes only the outstanding characteristics of each material. Where specific property ranges are cited, values are given in terms of standard ASTM tests. Details of testing procedures can be found in *ASTM Standards, Vol. 6, '55.* Many other specific properties must be investigated before selecting a material. The summary here should give you a good basis for investigating further the specific types of plastics that may answer your design needs.

Thermoplastics

ABS Materials

ABS materials are those containing acrylonitrile, butadiene and styrene monomers in varying proportions, both as terpolymers and blends (Cycolac, Royalite, etc.). Originally an outgrowth of polystyrene modification, the materials have properties so distinct from those of polystyrene that they are now classified separately.

They are exceptionally tough and strong. Izod impact strength runs about 3-9 ft-lb per in. notch (at –40 F these materials still retain values of 1.0-4 ft-lb per in. notch). Tensile strength is 5000-8000 psi; flexural modulus 195,000-470,000 psi. Toughness and strength can be altered substantially, but in general, when impact strength increases, stiffness decreases.

The materials are available as compounds for injection molding, extrusion, and calendering, and as sheet for thermoforming.

Typical applications include: pipe and fittings; appliance wheels; golf club heads; cases and housing for such equipment as radios and power mowers; textile bobbins; TV antenna brackets; refrigerator and auto parts; water pump impellers; football helmets; and utensil and tool handles.

Acetal

A hard material which looks and feels something like nylon, acetal (or polyformaldehyde) resin is one of the newest plastics. The only type announced to date (Du Pont's Delrin) should be commercially available in mid-'59. Outstanding properties include: 1) high strength and stiffness (tensile strength: 10,000 psi; modulus in flexure: 410,000 psi; Izod impact strength: 1.5-ft-lb per in. notch), 2) high heat resistance (ASTM heat distortion point under 264-psi load: 212 F; material can be used at temperatures as high as 250 F for short periods), 3) outstanding fatigue life, 4) low frictional characteristics, and 5) exceptional solvent resistance.

The material will be available in both injection molding and extrusion grades. Expected uses include: mechanical parts, such as gears and impellers; automotive parts, such as control cable sheathing; plumbing and hardware, such as shower heads and door handles; and appliance components and packaging containers.

Acrylics

The most widely used acrylic plastic is polymethyl methacrylate (Lucite, Plexiglas, etc.). A hard, rigid material, it is primarily notable for excellent optical properties as cast sheet (transmits about 92% of total light), and resistance to sunlight, weather and most chemicals. Heat resistance of most acrylics is limited to about 200 F maximum service temperature. Mechanically, acrylics are strong and rigid, but somewhat brittle (tensile strength: 8000-10,000 psi; modulus in flexure: 450,000-500,000 psi; Izod impact strength: 0.3-0.5 ft-lb per in. notch). A high impact molding compound is available, providing impact strengths of about 2 ft-lb per in. notch.

- Cast sheet, though somewhat expensive (as high as $2.15 per lb vs 51-59¢ per lb for molding compounds), has optical properties similar to glass, but is easier to scratch. Applications include aircraft and architectural glazing, contact lenses and other optical parts.
- Injection molding and extrusion grades also have good optical properties, though not as good as those of cast sheet. The high light transmission, coupled with a smoothly polished surface permits piping of light around corners. Typical applications include: hairbrush backs; auto taillights and medallions; edge-lighted parts, such as instrument panels; and display signs.

New developments to watch include . . . Syrup-form acrylic for weather resistant reinforced plastics panels . . . Chlorinated acrylic molding material which provides heat distortion values of about 260 F and can be immersed in boiling water without discoloration.

Cellulosics

The five most common cellulose plastics have in common excellent colorability and toughness, and ease of fabrication. Fire resistant grades are available. Generally cellulosics should not be used at temperatures much above 170-200 F.

Cellulose acetate

Lowest in cost of the cellulosics (as low as 36¢ per lb), cellulose acetate has good moldability, toughness and rigidity (Izod impact strength: 0.4-5.2 ft-lb per in. notch; modulus in flexure: 110,000-400,000 psi). It is available in a variety of grades, ranging from hard to soft.

- Injection molded acetate is used for such things as nailable shoe heels, combs, buttons, toys, toothbrushes, business machine keys and eyeglass frames.

- Sheet or film can be produced clear or colored and is used for vacuum formed parts, such as food trays, visors or displays. Other uses: packaging, sound tapes, coil insulation and pressure sensitive tape.

Cellulose acetate butyrate

Slightly more expensive (lowest price about 40¢ per lb) than acetate, butyrate is somewhat tougher, with a horn-like quality, and has lower moisture absorption (1.3-2.2% in 24 hr vs 1.9-6.5% for acetate). It has relatively good weatherability and excellent moldability.

- Injection molded, typical applications include telephone handsets, auto steering wheels, white sidewall disks, film spools, radio housings and fluorescent light supports.

- Sheet can be produced clear or colored and is used for outdoor signs, as a substitute for glass in hazardous areas, and for outdoor phone booths.

Cellulose propionate

Costing about the same as butyrate (40¢ per lb min), propionate has properties quite similar to those of butyrate. Tensile strength, modulus and impact strength are somewhat higher. Molded or extruded propionate is used for transistor radio cabinets, pen and pencil barrels, and auto parts such as arm rests.

Ethyl cellulose

Ethyl cellulose is 1) exceptionally tough over a wide temperature range (Izod impact strength: general purpose grades—1.7-6 ft-lb per in. notch; high impact grades—3.5-7.0 ft-lb per in. notch; –50 F impact strength: 2 ft-lb per in. notch), 2) moderately low in moisture absorption (1-2% in 24 hr), and 3) available in self-lubricating grades.

Typical uses include: refrigerator breaker strips and aircraft components where low temperature toughness is required; garage door roller wheels; luggage end caps; lawn mower rollers; flashlight housings; and tool handles.

Cellulose nitrate

Cellulose nitrate, the first plastic developed (Celluloid), is comparatively little used today because of its flammability. It is not available as a molding compound, but is available as a tough, easily formed sheet. It is used for such things as eyeglass frames and dice.

A reinforced cellulose nitrate material (Celastic) consists of flannel impregnated with a fire retardant cellulose nitrate. Available in sheet form, the material can be solvent-activated to permit easy forming. The solvent then evaporates, leaving a rigid formed part.

Plastics . . . what are they . . .

Plastics generally are organic high polymers (i.e., they consist of large chain-like molecules containing carbon) which are formed in a plastic state either during or after their transition from a small-molecule chemical to a solid material. Stated very simply, the large chain-like molecules are formed by hooking together short-chain molecules of chemicals (monomers) in a reaction known as polymerization. When chemically similar monomers are hooked together, the resulting plastic is a polymer, such as polyethylene made from the ethylene monomer. When chemically dissimilar monomers are hooked together, the process is called copolymerization and the resulting plastic a copolymer, such as PVC copolymers made from monomeric vinyl chloride and vinyl acetate.

. . . why are they used?

Although each type of plastic has unique properties, most all plastics offer certain similar benefits which have accounted for their wide usage: 1) light weight, 2) corrosion resistance, 3) electrical insulation, 4) thermal insulation, 5) ease of fabrication, which in many cases far offsets a higher materials cost, and 6) transparency.

On the other hand, these advantages often may be offset by disadvantages common to many plastics: 1) comparatively low strength, 2) low dimensional stability, 3) relatively low heat resistance, 4) generally poor weatherability, and 5) relatively high materials cost, which may or may not be a factor, depending on the material, the use, and the production volume and production method used.

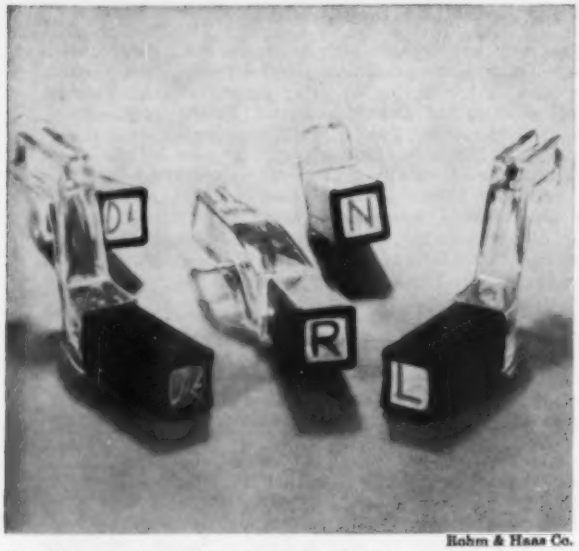
Fluorocarbons

Two basic types of fluorocarbon plastics are available: TFE (tetrafluoroethylene — Teflon) and CFE (chlorotrifluoroethylene—Kel-F, etc.). Outstanding properties include inertness to most chemicals and resistance to high temperatures (maximum recommended continuous service temperatures: 500 F for TFE; 390 F for CFE). Fluorocarbons have a rather waxy feel, extremely low coefficient of friction, and excellent dielectric properties which are relatively insensitive to temperature and power frequencies (volume resistivity: 10^{18} ohm-cm; dielectric strength: 400-500 v per mil for TFE, 530-600 for CFE; dissipation factor: 0.0002 from 60 to 10^6 cps for TFE; for CFE, 0.02 at 60 cps and 0.007 at 10^6 cps). Mechanical strength is comparatively low. Both materials are expensive, TFE being about $4.50 and CFE about $7 per lb.

TFE

In addition to being more heat resistant, TFE has higher chemical resistance than CFE. TFE is inert to nearly all chemicals, with the

Thermoplastics are often used for their light transmission and weatherability . . .



Rohm & Haas Co.

***Acrylics** can be used to pipe light. In these automatic transmission selector buttons for American Motors' Rambler, a clear acrylic is used in the core to pipe light to the button face; a high impact acrylic sleeve is shrink fitted around the core to provide a hard, scratch resistant surface and decorative variety.*

Eastman Chemical Products, Inc.

***Cellulose acetate butyrate** forms a tough, transparent, weather resistant cover for newspaper vending stands. Cover is vacuum formed and riveted to metal frame.*

exception of metallic sodium, other alkali metals, and certain halogenated chemicals at high temperatures and pressures. TFE has the lowest friction coefficient of any material, and can be used unlubricated. Compared with CFE, TFE is more subject to cold flow and has generally lower mechanical strength and rigidity (tensile strength: 1500-3000 psi; modulus in flexure: 60,000 psi; impact strength: 2.5-4 ft-lb per in. notch).

Since TFE does not soften as other thermoplastics do, it must be either formed or extruded by a process similar to powder metallurgy. Powders are compacted to the desired shape and sintered.

Typical uses include nonlubricated bearings of all types, chemical resistant pipe and pump parts, and high temperature electronic parts such as missile radomes.

CFE

CFE has higher mechanical strength and rigidity (tensile strength: 4500-6000 psi; modulus in flexure: 175,000 psi; impact strength: 3.5-3.6 ft-lb per in. notch) and greater long-time load carrying ability than TFE. Although not as chemical resistant as TFE, CFE is inert to most corrosive chemicals and highly resistant to most organic solvents. In most cases where a chemical permeates CFE, only swelling occurs; CFE can subsequently be returned to its original state by heating.

The major attribute of CFE is its ability to be molded and extruded by conventional thermoplastic forming techniques. A high degree of clarity can be obtained in thin sections by proper quenching. Typical applications for CFE include coil forms, chemical resistant pipe and pump parts, tank linings, connectors and valve diaphragms.

Other forms of fluorocarbon plastics include . . . Glass fabric-reinforced CFE and TFE for such applications as tank linings, gaskets and printed circuit bases . . . Filled TFE compounds, making use of a variety of inert fillers primarily to improve abrasion resistance and deformation under load . . . Extrudable TFE, which can be injection molded or extruded on standard equipment. Some sacrifice is made in heat and chemical resistance.

Nylons

The mechanical toughness and durability, good abrasion resistance, good dielectric properties, low frictional characteristics, good chemical stability and relatively high heat resistance of nylons fully justify their relatively high cost (slightly over $1 per lb) for a variety of applications. Nylons have tensile strength on the order of 8000-10,000 psi, Izod impact strength of about 2 ft-lb per in. notch, and moduli in flexure of 210,000 to 410,000 psi, depending on moisture content. They can generally be used over a temperature range of –40 to 250 F.

Nylons are resistant to most solvents, and particularly resistant to petroleum oils and greases, alkalis, lactic acids and photographic solutions. They are generally soluble in molten phenol and hot formic acid, and are attacked by concentrated solutions of mineral acids.

Nylon has good dielectric properties at commercial power frequencies (dielectric strength: 385-470 v per mil; volume resistivity: 4.5 x 10^{13} ohm-cm; dissipation factor: 0.01-0.09). Nylon makes an excellent in-

sulating material, particularly where mechanical durability and resistance to oils and greases are required.

Injection molded or extruded nylon is used for such things as gears, cams and other sliding contact devices for cars, business machines, sewing machines, stoves and refrigerators; slide fasteners; door hinges; gaskets; wire insulation; coil forms; high pressure flexible tubing; and boat propellers.

Special types and formulations of nylons are available. Among these are . . . Stabilized formulations with resistance to specific environments, such as heat and light . . . Filled nylons for improved wear resistance and deformation under load . . . Sintered nylons for improved frictional and bearing characteristics . . . Chopped glass-reinforced nylon injection molding compounds for improved strength and dimensional stability . . . Alcohol-soluble nylons for coating and impregnation of fabrics, leather and hard goods . . . Nylon sheet and film for packaging.

Polycarbonates

Only one type of this new plastic is currently available (G.E.'s Lexan, available in semi-commercial quantities). Primary features are: 1) extreme toughness (Izod impact strength: 12-16 ft-lb per in. notch),

A SUMMARY OF PROPERTIES, FORMS AND COST

Material ↓	Primary Reasons for Use[a]: Strength and Rigidity	Toughness	High Dielectrics	Chemical Resistance	Low Moisture Absorption	Weatherability	Colorability	Optical Clarity	Flexibility	Heat Resistance	Max Continuous Svc Temp, F[b]	Forms Commonly Produced: Injection Moldings	Compression or Transfer Moldings	Extrusions	Castings	Reinforced Plastics Moldings	Industrial Thermosetting Laminates	Formable Sheet	Film	Fiber	Foam[c]	General Price Range, ¢/lb[d]
THERMOPLASTICS																						
ABS Material	X	X	O	O	....	O	X	....	....	....	225	√	....	√	....	....	....	√	....	....	....	50-60
Acetal	X	O	O	O	....	....	X	....	....	X	225	√	....	√	....	....	....	....	....	....	....	95
Acrylics	X	....	....	O	....	X	....	X	....	....	190-200	√	....	√	√	....	....	√	....	√	....	51-59[e]
Cellulose Acetate	X	X	O	....	....	....	X	X	....	....	180-200	√	....	√	....	....	....	√	√	√	....	36-65
Cellulose Acetate Butyrate	X	X	O	....	X	X	X	X	....	....	180-200	√	....	√	....	....	....	√	√	....	....	40-72
Cellulose Propionate	X	X	O	....	X	....	X	X	....	....	180-200	√	....	√	....	....	....	√	√	....	....	40-72
Chlorinated Polyether	....	....	....	X	X	....	....	....	....	X	300	√	....	√	....	....	....	....	....	....	....	600
Ethyl Cellulose	O	X	....	....	....	....	X	....	X	....	180-200	√	....	√	....	....	....	....	....	....	....	67-80
TFE-Fluorocarbon	....	O	X	X	X	X	....	....	....	X	500	....	√[f]	√	....	....	....	√	√	√	....	450-745
CFE-Fluorocarbon	O	....	X	X	X	X	....	....	....	X	390	√	....	√	....	....	....	√	√	....	....	700-800
Nylon	X	X	O	O	....	....	O	O[g]	....	X	250	√	....	√	....	....	....	√	√	√	....	118-200
Polycarbonate	X	X	....	X	O	X	O	....	....	X	300	√	....	√	....	....	....	....	....	....	....	250[h]
Polyethylene	X	X	X	X	X	....	O	X[g]	X	....	175-212	√	....	√	....	....	....	√	√	√	R	33-43
Polypropylene	X	X	X	X	X	....	O	X[g]	....	X	230	√	....	√	....	....	....	√	√	√	....	47
Polystyrene	X	....	X	O	....	....	X	X	....	....	140-160	√	....	√	....	....	....	√	√	....	....	25-44
Modified Polystyrene	X	X	O	X	....	....	X	....	....	X	212	√	....	√	....	....	....	√	√	....	....	25-44
Vinyl	X	X	X	X	O	....	X	X[g]	X	....	175	√	....	√	√	....	....	√	√	√	F, R	27-43
THERMOSETTING PLASTICS																						
Epoxy	X	....	X	X	X	X	X	....	....	....	300-350	....	....	....	√	√	√	....	....	....	R	65
Melamine	....	....	X	O	X	....	X	....	....	....	210-250	....	√	....	....	√	√	....	....	....	....	42-45
Phenolic	X	O	O	O	....	....	....	....	....	X	350-400	....	√	....	√	√	√	....	....	....	R	17-40
Polyester (other than molding compounds)	X	O	O	O	....	....	X	X	....	....	300-400	....	....	....	√	√	√	....	√	√	....	32-50
Polyester (alkyd, DAP)	O	O	X	....	X	....	....	....	....	X	450-500	....	√	....	....	√	√	....	....	....	....	34-53
Silicone	....	....	X	....	X	....	....	....	....	X	550	....	√	....	√	√	√	....	....	....	R	168-540[i]
Urea	....	....	....	O	....	....	X	....	....	....	170	....	....	....	....	....	....	....	....	....	....	19-33

[a] X = One of the most important reasons for using the material. O = A secondary, but relatively important, reason for using the material. Absence of a symbol does not necessarily mean that the property is lacking, simply that it is not outstanding enough to be a primary reason for use of that material. Nor does presence of a symbol mean that the property is outstanding in comparison with other plastics. For quantitative comparisons, see text.

[b] General comparative values. Actual maximum temperatures for a given grade will depend on formulation and condition of service.

[c] "R" means rigid foams available; "F" means flexible.

[d] Prices are for resins or molding compounds in large quantities; prices of special formulations or for converted materials vary considerably. Cost per unit volume is much lower because of low weight of plastics (general range: 0.03-0.08 lb per cu in.); different densities of materials may also substantially alter comparative costs of materials on a unit volume basis.

[e] As high as $2.15 per lb for cast sheet.

[f] Formed by technique similar to powder metallurgy.

[g] In film form.

[h] Introductory price; commercial price expected to be $1.00-1.30 per lb.

[i] Laminating and casting resins: $1.68-1.89; molding compounds: $2.75-5.40.

. . . decorative, low cost dielectric characteristics . . .

Celanese Corp. of America

Cellulose acetate *(flame resistant grade) provides colorful, low cost, flame resistant housings for electrical appliances such as mixers and knife sharpeners.*

Koppers Co. Inc.

Polystyrenes, *either transparent or in a variety of colors, are used for such applications as Philco TV screen and mask, Zenith radio cabinet, freezer compartment door and Sinko lighting louver (above). Modified styrenes provide high impact strength for such things as the first one-piece all-plastic refrigerator cabinet (below).*

Dow Chemical Co.

2) high heat resistance (melting point: 514 F; ASTM heat distortion point under 264-psi load: 280-290 F), 3) high strength and rigidity (tensile strength: 9000-11,000 psi; modulus in flexure: 380,000 psi), 4) high resistance to creep, and 5) good fatigue strength.

Polycarbonate is stable in water (moisture absorption: 0.3% in 24 hr), and in mineral and organic acids; it is insoluble in aliphatic hydrocarbons, ether and alcohols. It is partially soluble in aromatic hydrocarbons, and soluble in chlorinated hydrocarbons.

Available for injection molding or extruding, polycarbonate is being used for gears, automotive parts, structural housings, hydraulic fittings, coil forms, decorative and functional appliance parts, and electronic components.

Polyethylene

Polyethylenes (polyolefin resins, i.e., hydrocarbons with at least one double bond between adjacent carbon atoms) are of three general types, classified by ASTM as: Type I, lower density (0.910-0.925 gm per cu cm); Type II, intermediate density (0.926-0.940) and Type III, higher density (0.941-0.965). All three have in common: 1) toughness, 2) a waxy feel, 3) excellent dielectric properties (dielectric strength: 480 v per mil; volume resistivity: $> 10^{16}$ ohm-cm; dissipation factor: < 0.0005), 4) a high degree of colorability, 5) near-zero moisture absorption ($< 0.01\%$ in 24 hr), and 6) excellent resistance to acids, alkalis and solvents. Although embrittled by ultraviolet light, all types can be compounded with carbon black for excellent weatherability. Polyethylene is relatively inexpensive, ranging in price from about 31 to 37¢ per lb.

The primary differences between the three types of polyethylenes are in rigidity, temperature resistance and ability to sustain loads. In general, increasing density is accompanied by increasing stiffness, strength, hardness and heat resistance, and decreasing impact strength and resilience.

Lower density materials are quite flexible (stiffness modulus: 13,000-27,000 psi) with high impact strength and relatively low heat resistance (maximum recommended service temperature: 140-175 F).

Intermediate density materials have a stiffness modulus of about 43,000-50,000 psi, and a maximum continuous service temperature of about 160-200 F. They can be sterilized.

Higher density materials have stiffness in flexure of about 85,000-150,000 psi and maximum continuous service temperature of over 200 F. Whereas the lower and intermediate density materials are so flexible that they do not break completely in the notched Izod impact strength test, higher density materials have impact strength values ranging from about 1 to 14 ft-lb per in. notch, depending on the resin.

Polyethylenes are used in a variety of fabricated forms:

- Injection molded polyethylenes of all three types are used for: housewares, such as mixing bowls, colanders and utensils; sprinkler heads for garden hose; fittings for pipe; handles for paint brushes and rollers; and fire extinguisher horns. The higher rigidity of higher density materials has led to their use in housings for such appliances as power saws and lawn mowers.
- Blow molded containers such as squeeze bottles and carboys are predominantly made of polyethylene.
- Extruded polyethylene is being widely used for pipe and profile shapes as well as coating for wire and cable.
- Sheet can be economically thermoformed into light diffuser panels, industrial and sports helmets, luggage, and parts for refrigerators and other appliances.
- Film can be produced clear, translucent or colored.
- Foam or cellular polyethylene is in limited use, primarily for electrical insulation or flotation.

Other interesting types of polyethylene include . . . Crosslinked (chemically or by irradiation) polyethylene is essentially an infusible thermosetting material, with high heat resistance . . . Copolymer olefins, consisting of ethylene and another olefin monomer, are similar to polyethylene in most characteristics, but have greatly improved creep resistance, load carrying capacity, and resistance to environmental stress cracking.

Polypropylene

Polypropylene, also a polyolefin, is somewhat similar to higher density polyethylenes in properties and appearance. It differs in that it is lighter (0.90-0.91 gm per cu cm), more rigid (stiffness in flexure: 114,000-142,000 psi) and resistant to higher temperatures (maximum continuous use temperature: about 230 F). Impact strength is 1.02 ft-lb per in. notch. Polypropylene has excellent resistance to creep and environmental stress cracking. It also has low water absorption (0.03% in 24 hr) and low permeability to water vapor and solvents.

First of the "isotactic" polymers, in which the molecule is tailored to provide desired properties, polypropylene is still a new material in terms of commercial uses. It is available for molding and extrusion, and as sheet, fiber and film. Uses are expected to include: structural parts such as pipe and housings; automotive and appliance parts; electrical components, such as microphone cases and recorder housings; parts involving sliding contact, such as cams and gears; textiles and rope; and packaging applications where superior strength and heat resistance are required.

Polystyrenes

Polystyrene is one of the largest and most widely used families of plastics. Primary attributes of general purpose polystyrene are: 1) low cost (about 25¢ per lb), 2) virtually unlimited colorability, 3) ability to be made crystal clear, 4) hard, glossy surface (Rockwell hardness: M80-90), and 5) excellent dielectric properties (dielectric strength: 500 v per mil; volume resistivity: 10^{16} ohm-cm). General purpose polystyrene has a relatively low impact strength—about 0.25-0.35 ft-lb per in. notch, and a low maximum service temperature—140-160 F, or in some cases 180 F.

Many different types of modified polystyrenes are available, each suited to a particular type of service. Modifications may have been accomplished by such means as mechanical blending, copolymerization or substitution in the styrene monomer. The important types of modified polystyrenes include the following:

1. *Chemical resistant styrene-acrylonitrile copolymers* provide additional resistance to solvents, oils and other organic liquids.

2. *Medium, high, and extra high impact styrene-butadiene* materials are classified by the impact strength (i.e., 0.6-1, 1-3 and 4.6-15.0 ft-lb per in. notch) provided by increasing quantities of butadiene in the resin. As impact strength increases, rigidity decreases. The materials are available in a wide range of colors, but cannot be produced crystal clear.

3. *Polymethylstyrene, and methylstyrene-acrylonitrile copolymer* materials are based on a substituted styrene monomer. Polymethylstyrene has essentially the same properties as polystyrene plus improved heat resistance, permitting continuous use at temperatures up to 212 F. The methylstyrene - acrylonitrile copolymer has the same properties as polymethylstyrene, plus improved chemical resistance, and greater toughness, craze resistance and resistance to thermal shock. An electrical grade of polymethylstyrene is also available.

4. *Glass-reinforced polystyrene* injection molding compounds provide higher strength and durability than polystyrene.

- Injection molded, extruded or thermoformed polystyrene sheet is used in a variety of applications, including wall tiles, radio and other appliance housings, refrigerator parts, storage boxes, cutlery handles, containers, vials, housewares, oil-filter and gasoline-pump bowls, toys, and rigid food containers.
- Film is available with a high degree of clarity or in a variety of colors.
- Rigid foams of polystyrene are available either as prefoamed plank, sheet or block, or as expandable beads which are placed in a mold and expanded by heating. Typical uses for styrene foam include thermal insulation, flotation gear and novelty display items.

Vinyls

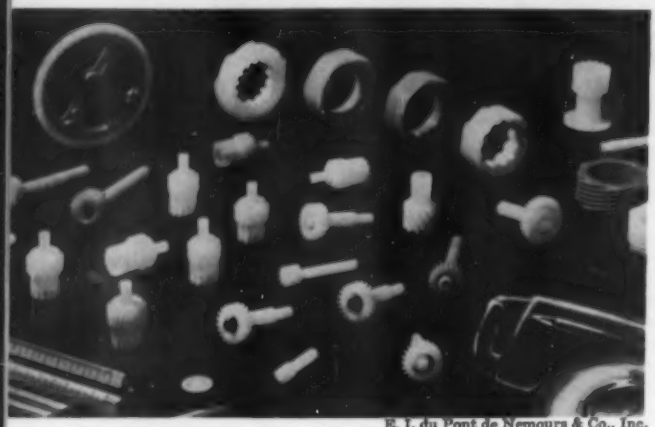
Although the term "vinyls" chemically includes a broad range of materials (including polystyrenes), it is usually used loosely to refer to PVC (polyvinyl chloride) or PVC copolymers. The most common copolymers are vinyl chloride-vinyl acetate and vinyl chloride-vinylidene chloride (Saran, etc.).

PVC and PVC-acetate copolymers

These materials can be formulated to provide such diverse combinations of properties that simple characterization by properties is difficult. In general, PVC materials are tough, with high inherent strength and abrasion resistance, exceptional resistance to a wide variety of chemicals, and virtually unlimited colorability. They have excellent dielectric characteristics, do not support flame, are nontoxic and resist moisture. In general, PVC can be used over a temperature range of –65 to 175 F, though higher temperatures can be tolerated in some cases.

Basically PVC materials can be classified as rigid or flexible. Rigid PVC is essentially unplasticized. It has a Shore hardness of D75-85 (similar to hard rubber), an impact

. . . toughness, strength, dimensional stability . . .

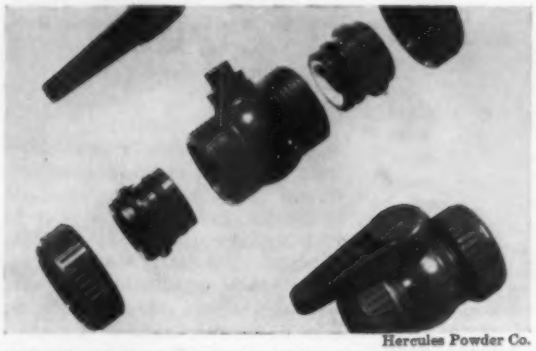


E. I. du Pont de Nemours & Co., Inc.

***Nylon,** in addition to toughness, strength and dimensional stability, has abrasion resistance and low frictional properties to make it widely used in mechanical applications such as auto gears and bearings.*

Phillips Chemical Co.

***Polyethylenes** of the rigid type III variety are used for appliance and tool housings, e.g., these parts for the new Toro power mower.*



Hercules Powder Co.

***Polypropylene,** similar to higher density polyethylene, except for higher rigidity, heat resistance and chemical stability, is used for such things as pipe fittings where toughness, corrosion resistance or relatively high temperatures are encountered.*

Dow Chemical Co.

***Ethyl cellulose** provides high impact strength, even at low temperatures, for such applications as this headlight aimer housing. The material is also colorable, and has a glossy, easy-to-clean, attractive surface.*

***Vinyls** are used for tough water pipe on this destroyer to permit thorough wash-down after exposure to radiation fall-out. Material resists all types of corrosion and has good toughness over wide temperature range.*

Tube Turns Plastics, Inc.

strength of 0.25-1.2 ft-lb per in. notch, and modulus in flexure of 380,000-540,000 psi. It is difficult to injection mold and is usually compression molded, calendered, laminated or extruded. Typical uses include fume hoods and ducts, storage tanks, chemical piping and plating tanks.

Flexible or plasticized PVC has elastomeric properties. It can be formulated with a variety of fillers, plasticizers, stabilizers and pigments in various proportions to provide a wide range of characteristics. Typical property ranges include: Shore hardness: A50-100; tensile strength: 1000-3500 psi; elongation: 200-450%; 100% modulus: 1200-2800 psi. A cold flex temperature of about –70 F is obtainable.

- Extruded flexible PVC is used for such applications as: insulation and jacketing on electric wire and cable; garden hose; refrigerator, window and automotive gaskets; and trim on luggage.

- Film and sheet are widely used in protective clothing such as raincoats and aprons, shower curtains, furniture and auto upholstery, handbags and belts.

- Laminates of sheet or film and textiles are used for outer clothing and upholstery. Laminates of sheet adhesive bonded to sheet metals (e.g., steel, aluminum or magnesium) can be formed by conventional sheet metal fabricating techniques into a variety of shapes. Applications include cabinets and housings for radios, TV, and office machines; luggage; paneling; and auto trim.

- Plastisols (liquid combinations of vinyls and plasticizers) and organosols (plastisols containing solvents) can be slush molded to form a variety of products such as dolls and balls.

- Flexible PVC foams, formed from plastisols either by mechanical mixing or with the aid of chemical blowing agents, are used for cushioning, e.g., taxi jump seat padding, and furniture seats and backing.

Polyvinylidene chloride

Actually a copolymer of vinylidene chloride and vinyl chloride, the material is probably best known as film or fiber. It can also be molded and extruded. Its primary attributes are excellent resistance to all acids and most common alkalis, and excellent weatherability (may darken slightly during first few months of exposure). Maximum service temperature is about 212 F. As film, polyvinylidene chloride has been widely used for packaging, particularly of foods. Fibers are used for garden furniture and auto seat upholstery.

In extruded form, this plastic is used for gasket rods, valve seats, flexible chemical tubing and pipe, and chemical conveyor belting. As moldings, common uses include spray gun handles, acid dippers, and parts for machinery such as rayon producing equipment.

Other vinyls include . . . Polyvinyl acetate, primarily used for coatings and adhesives . . . Polyvinyl butyral, used for transparent elastic interlayers for safety glass . . . Polyvinyl alcohol, a water-soluble, tough, flexible plastic, impervious to gases and water-insoluble solvents.

More Information

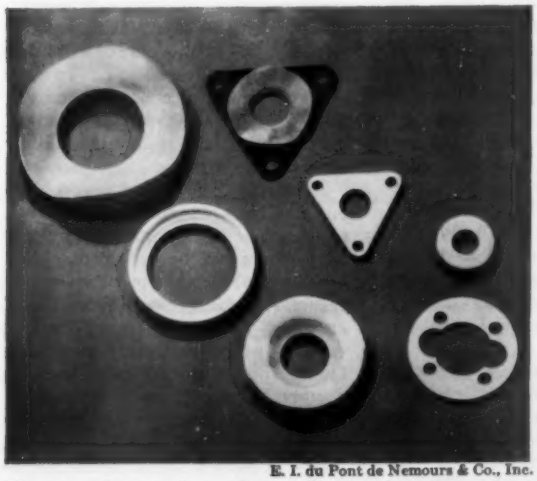
More detailed data on properties and a list of the suppliers of each of the various groups of plastics discussed in this manual may be found in the *Materials Selector*, Mid-Oct issue, M/DE.

Chlorinated polyether

Chlorinated polyether (Hercules' Penton) is a relatively new commercial material. It is an expensive ($6 per lb), premium material, somewhat similar o the fluorocarbons in that it has excellent resistance to a variety of chemicals. It is formstable under zero load at temperatures up to 300 F. It has good load-bearing characteristics and excellent abrasion resistance, and it can be easily extruded or injection molded.

Major applications should be for parts such as pumps, valves and fittings for corrosive environments.

. . . outstanding chemical resistance



E. I. du Pont de Nemours & Co., Inc.

***Fluorocarbon resins** make excellent gaskets for systems handling highly corrosive chemicals both at low and high temperatures. Gaskets shown are TFE fluorocarbon.*

Polymer Corp. of Pa.

***Chlorinated polyether** flange gasket is used as a seal between open glass feeder pipe and metal specimen in heat transfer equipment for corrosion testing of metals.*

Thermosetting plastics

Epoxies

Epoxy resins provide: 1) outstanding adhesion to both metallic and nonmetallic surfaces, 2) excellent chemical resistance, 3) low moisture absorption (0.01-0.2% in 24 hr), 4) excellent dielectric properties (dielectric strength: 350-550 v per mil; volume resistivity: 8 x 10^{15} ohm-cm; dissipation factor: 0.001-0.002 at 60 cps), and 5) high strength in reinforced laminate form. Epoxies are usually rigid materials, but can be produced in flexible, resilient form. Maximum recommended service temperatures generally range about 300 to 350 F. Epoxies can be cured at either room or elevated temperature, though heat cure provides maximum properties. Several basically different curing systems can be used to provide different characteristics in the cured material.

In comparison with other thermosets, epoxies are relatively expensive —about 65¢ per lb. As plastics (excluding adhesives and coatings), epoxies are available as casting and foaming resins, laminating resins for reinforced plastics, and more recently as molding compounds.

Casting and foaming resins are primarily used for potting or encapsulating electrical or electronic equipment. Epoxy's excellent adhesion and extremely low shrinkage (about 0.001-0.01 in. per in.), coupled with high dielectric properties, provides a well sealed, voidless, well insulated component.

Resins are also formulated with a variety of fillers, such as metal powder, to provide effective patching and repair putties or pastes. Such compounds can be used to patch both metal and plastic surfaces.

Laminating resins are used to produce low pressure reinforced laminates and moldings, high pressure industrial thermosetting laminates (NEMA Grade G-10 glass cloth-base laminate for mechanical and electrical uses), and filament-wound shapes. Properly prepared glass-reinforced epoxy laminates offer the highest mechanical strength of any reinforced plastics material, as well as outstanding chemical resistance. Price has generally limited use of such laminates to critical parts, such as high strength-to-weight aircraft parts (often where chemical resistance is an additional requirement); chemical tanks; pipe; and bases for printed circuits.

Epoxy laminates are also widely used in plastics tools. They are used for drilling, checking and locating fixtures where dimensional accuracy is critical. They are also used to provide durable surfaces for metal-forming tools, such as draw dies for short-run production. In such applications, backing for the laminate surface may be cast epoxy or a variety of other materials.

Filament-wound epoxy structures are used for such applications as aircraft radomes and pressure vessels.

Molding compounds based on epoxies are still relatively new. A major problem in their development has been effective mold release. Several compounds are now available with mold release characteristics built into the resin.

New developments to watch include . . . Two developmental epoxy materials which promise substantially increased heat resistance (i.e., ASTM heat distortion temperature under 264-psi load approaching 600 F), and possibly reduced cost . . . New metering spray gun for epoxies, which may permit economical use of chopped glass-epoxy systems for such structures as boat hulls.

Melamines

Melamine formaldehyde, an amino resin, is probably the hardest of plastics (Rockwell M119-124). Its major features include: 1) unlimited colorability, 2) high dimensional stability, 3) low moisture absorption (0.09-0.5% in 24 hr), 4) flame resistance, 5) excellent dielectric characteristics (arc resistance: 100-180 sec; dielectric strength: 350-430 v per mil), and 6) high temperature resistance (maximum recommended service temperature: 210-250 F). Melamines are relatively high in cost, i.e., 42-45¢ per lb. They are available both as molding compounds and as high pressure industrial thermosetting laminates.

Molding compounds are available with a variety of fillers, including alpha cellulose, minerals, fabric and glass fiber. In molded form melamines are used primarily for: 1) dinnerware (usually alpha cellulose-filled), making use of melamine's colorability, hardness and scratch resistance, and resistance to oils and greases, and 2) electrical components, particularly where arc resistance is critical, such as ignition parts, circuit breakers and terminal blocks. Other uses for moldings include aerosol bottles, boil-resistant buttons, housings for coffee makers, soda dispensers, and flatware and cutlery handles.

High pressure industrial thermosetting laminates, using melamine binders include the following NEMA types: Grade ES-1 paper-base engraving stock; Grade MC cotton-base alkali and arc resistance stock; and Grade G-5 glass-base high strength electrical stock.

Most decorative thermosetting laminates (Formica, Micarta, etc.) used for table, appliance and counter tops and for wall covering have melamine surfaces. Hardness, washability and colorability are the primary reasons for the choice of melamine.

Phenolics

The oldest commercial thermosetting plastics, phenol formaldehyde resins (often called Bakelite after their inventor) are primarily notable for: 1) strength and rigidity (tensile strength: 5000-9000 psi; modulus in flexure: 1-2 million psi), 2) dimensional stability, 3) resistance to heat (maximum service temperature: 350-400 F common, 600 F obtainable in certain compounds), 4) chemical resistance, and 5) good dielectric characteristics (dielectric strength: 250-460 v per mil; volume resistivity: 10^{11} -10^{13} ohm-cm; dissipation factor: 0.01-0.25 at 60 cps). In general, phenolics cost only about 21-40¢ per lb for molding compounds, 17-34¢ per lb for liquid casting resins.

Phenolics are limited in colorability. They are naturally brown, and darken on aging. Thus some dark colors can be produced. They are available as compression or transfer molding compounds; liquid casting, laminating or foaming resins; preimpregnated sheet for laminating; and high pressure industrial thermosetting laminates.

• Molding compounds are available with a variety of different types of fillers. Common fillers include woodflour, cellulose, cotton flock, macerated rag, asbestos, mica, sisal and glass. Compound grades include

Simple Ways to Identify Plastics

The simple tests given here should be used only for tentative identification. The results should never be accepted as positive identification. The complexity of some plastics may make the results inconclusive and confusing.

Little equipment needed

Simple burning is the most generally useful test. Equipment needed is a match, or preferably a bunsen burner, and a pair of tongs to hold the sample. Samples should be slivers about 3 in. or more long and about ⅛ in. thick.

The other tests given require 1) stirring rod, 2) small bottle of 1:1 hydrochloric acid (HCl) and another bottle of 1 part concentrated nitric acid (HNO_3) and 3 parts HCl, and 3) a dish of water.

The procedure

To determine initially whether a material is thermosetting or thermoplastic, heat the stirring rod (to about 500 F) and press it against sample. If sample softens, material is thermoplastic; if not, it is thermosetting.

Next, hold the sample to the edge of the flame until it ignites. (Hold in flame for about 10 sec if no flame is produced immediately.) If the material burns, note the color of the flame, then extinguish the flame and cautiously smell the fumes. (In identifying odor, a known sample is most helpful for comparison.) Finally, check your observations against the following outline:

I. No flame is produced:
- A. Sample deforms slowly:
  1. Caution—fumes may be toxic. Sample is not attacked by mixed HNO_3 and HCl—**Fluorocarbon.**
  2. Hydrochloric acid odor—**Vinylidene chloride or PVC polymer or copolymer.**
- B. Retains shape; odor of formaldehyde:
  1. No other odor—**Urea.**
  2. Strong, fishlike odor—**Melamine.**
  3. Odor of phenol—**Phenolic** (inorganic filler).

II. Burns, but extinguishes itself upon removal of flame:
- A. Yellow flame; ignites with difficulty:
  1. Acrid odor; green spurts—**PVC.**
  2. Odor of phenol, mixed with that of burning wood or paper—**Phenolic** (organic filler).
  3. Sparks from flame; acetic odor, resembling vinegar—**Cellulose acetate** (flame resistant).
- B. Blue flame; yellow tip; melts and drips; odor of burning wool or hair; slowly soluble in HCl—**Nylon.**

III. Continues to burn after removal from flame; flame examined for color during first second of burning:
- A. Burns slowly, or self-extinguishing; black smoke; sharp, acrid odor similar to that of phenolic; sample may be light colored—**Epoxy.**
- B. Burning very rapid; intense white flame—**Cellulose nitrate.**
- C. Slow burning with clear, smokeless blue flame; faint odor of formaldehyde—**Acetal.**
- D. Flame blue, yellow at top:
  1. Fruity odor—**Acrylic.**
  2. Odor of burning wool or hair; resin slowly soluble in HCl—**Nylon.**
  3. Melts and drips; drippings may burn:
     a. Rancid butter odor—**Cellulose acetate butyrate.**
     b. Pungent odor—**Cellulose propionate.**
  4. Melts and drips; drippings burn; paraffin odor similar to that of burning candle; floats on water:
     a. **Polyethylene**—Lower density (Type I) is flexible; higher density Type II and III harder, more rigid.
     b. **Polypropylene**—Rigidity similar to that of high density polyethylene; more difficult to scratch with fingernail.
- E. Flame yellow:
  1. Melts and drips, drippings may burn; acetic odor, resembling vinegar—**Cellulose acetate** (non-flame resistant).
  2. Dense smoke, with flecks of soot in air:
     a. Odor of artificial illuminating gas—**Polystyrene.**
     b. Acetic odor—**Vinyl acetate.**
  3. Flame blue at edges:
     a. Melts; drips; drippings may burn:
        1) Odor of burnt sugar—**Ethyl cellulose.**
        2) Odor of rancid butter—**Cellulose acetate butyrate.**
     b. Cracks and breaks—**Polyester** (non-fire resistant).

Source: "Quick Identification of Plastics," MATERIALS & METHODS, Apr '48, with additional data from materials suppliers.

general purpose, shock resistant, high shock resistant, high frequency insulation, shock and heat resistant, and many others.

Applications for molding compounds are many and varied. Among the most common are light plugs and switches, switchboxes, TV and radio cabinets, electric iron handles, appliance bases, and parts for vacuum tubes.

• Casting resins are used for economically producing such parts as juke box housing components, marble-like fountain pen bases, buttons, poker chips and toys.

• Rigid phenolic foams are finding a number of uses, typical of which is thermal insulation for pipes in chemical processing plants.

• Laminates are mostly of the high pressure type. The majority of the NEMA standard grades of industrial thermosetting laminates (18 of the 25) are phenolic laminates.

One of the more startling recent uses for phenolic laminates is as missile components such as exhaust nozzles, combustion chamber liners and nose cones. Of reinforced plastics tested to date, phenolics have been found to erode least rapidly

and thus retain required properties longest at the 3000-25,000 F temperatures and high velocity gas streams encountered in missile applications. Of course, service life is limited to several seconds, minutes or at most about 1 hr. Reinforcing materials include asbestos or high silica glass fibers at the lower temperatures; nylon or other organic fibers at the higher temperatures.

Polyesters
(incl alkyd, diallyl phthalate)

The term "polyester" covers a large number of plastics. By definition, polyester resins are reaction products of dibasic acids and polyhydric alcohols. Unsaturated polyesters are usually crosslinked with a polymerizable monomer such as styrene (most common), triallyl cyanurate (TAC), or diallyl phthalate (DAP). DAP molding materials, though covered here, are not true polyesters as they are reaction products of a dibasic acid and an unsaturated monohydric alcohol.

Laminating and casting resins are the most commonly used form of polyester. As liquids, they are easy-to-handle and cure rapidly either at room or elevated temperature. Although polyesters with a variety of property combinations are available, their major common attributes are unlimited colorability, excellent dimensional stability and good dielectric properties. Polyesters are available in either rigid or flexible form, and can be made weather and light resistant, fire retardant and heat resistant. Polyesters are relatively low cost materials, prices ranging approximately from 32 to 50¢ per lb.

Polyesters are the most widely used resins for reinforced plastics produced by low pressure techniques. Though a variety of reinforcing materials can be used, the most common is glass cloth or mat. Such laminates can provide extremely high strength-to-weight ratios. While densities range around 0.05-0.08 lb per cu in. (1.5-2.2 gm per cu cm), tensile strength is 25,000-55,000 psi, flexural strength 40,000-75,000 psi, and modulus in flexure 2 to 4 million psi. Impact strength values range from 7 to 20 ft lb per in. notch. Dielectric properties can also be excellent (dielectric strength: 300-800 v per mil; volume resistivity: 10^{m} ohm-cm; dissipation factor: 0.01-0.04 at 60 cps; arc resistance: 90-190 sec).

Among the most common structural applications for reinforced polyesters are boat and car bodies (e.g., GM's Corvette), chairs, luggage, aircraft parts, architectural panels and partitions. Laminates are also used for electrical parts such as slot liners, and for corrosion re-

Forming and Converting Techniques

Following is a brief, simplified description of the more common methods of forming plastics materials. In addition, many special techniques are used.

Thermoplastics

Injection molding Similar to die casting metals. Granular polymer is fed to heating cylinder, where it is softened and fed, usually by plunger, into single or multicavity dies where material cools to form finished part.

Extrusion Similar to extrusion of metals. Granular polymer fed to heated screw chamber, where it is softened and fed through die the shape of desired finished cross section. In cross-head extrusion onto wire, wire or cable is fed into the die so as to be located at center of molten material as it is extruded from die. Extruded shapes other than tubular include profile shapes or slit sheet or film. Blown film is extruded in tubular form, then expanded by blowing to obtain desired molecular orientations thickness and width. Cast extruded film is slit-extruded and quenched, either on chilled rolls or in a water bath, to obtain clarity.

Blow molding Material (generally polyethylene) is usually tube-extruded to desired length, one end heat sealed, and section blown out by air pressure to fill mold of desired shape.

Calendering Heated material is fed between series of large heated rolls to produce sheet or film. Thickness of sheet or film determined by spacing between rolls.

Slush molding Material (usually vinyl) must be in form of liquid plastisol or organosol (see section on "Vinyls"). Liquid polymeric material is placed in closed mold. Rotational force often applied to obtain consistent coating of mold surface. Mold is heated to fuse material adjacent to mold surface. Mold is then opened, and unfused material emptied, leaving fused skin of desired shape.

Thermoforming Term used to cover variety of techniques for forming thermoplastic sheet. Most common method is vacuum forming, an economical technique in which sheet is softened by heating, placed over male (or female) mold, and the air evacuated from between sheet and mold, drawing softened sheet to contour of the mold. There are many modifications, such as vacuum snapback forming, plug assist and drape forming. Blow or pressure molding is reverse of vacuum forming, in that positive air pressure rather than vacuum is applied to form sheet to mold contour. Other thermoforming techniques: hot line bending, stretch forming, plug and ring forming, slip forming, ridge forming and die pressing.

Casting Not too commonly used with thermoplastics, except for cast acrylic sheet. Cast acrylic sheet formed by casting liquid monomer and polymerizing. In casting other thermoplastics, polymer is heated to liquid form, cast and allowed to cool.

Thermosets

Compression molding Molding compound, either in loose form or as preform (partially compressed tablet, in some cases similar to desired finished shape), is placed in open mold. Mold is closed and heat is applied, softening partially polymerized material and forcing it to flow and fill cavity. Heating of mold completes polymerization or cure of material in final form. Method sometimes used for thermoplastics, e.g., vinyl phonograph records.

Transfer molding Similar to compression molding in that material is cured in mold under heat and pressure. Differs from compression molding in that molding material is loaded in "transfer chamber" separate from mold cavity. During initial part of cycle, partially polymerized compound is forced through gates into mold, where material is cured. Used where precise feeding is required to aid molding of such shapes as small deep holes or to preclude shifting of small, delicate inserts.

sistant parts such as plating tanks.

TAC-polyesters (those using TAC as the polymerizable monomer) are primarily designed for high temperature applications. They combine good mechanical strength for continuous use at temperatures up to 500 F with exceptional transparency to radio waves of radar frequency. Their primary use is in reinforced plastic aircraft radomes.

As castings, polyesters are used for most buttons for men's shirts, as well as other types of clothing. Filled casting resins are used for electrical potting and encapsulation. An allyl-type polyester which has a high degree of optical clarity in the cast form is used for commercial aircraft glazing and architectural lighting fixtures and glazing.

Premix molding compounds are mostly polyesters. A variety of resins are available for mixing with a variety of reinforcing materials to produce economical parts of somewhat lower strength than cloth or mat-reinforced laminates. They can be molded rapidly into intricate shapes.

Typical parts produced with premix compounds include refrigerator striker plates, auto heater and air-conditioner ducts and housings, window frames, and parts for electrical equipment.

Alkyds

Alkyd molding compounds are dry polyester compounds designed for molding under pressure. They are primarily used for electrical applications. Their notable properties are: 1) good dielectric qualities (dielectric strength: 350-400 v per mil; dielectric constant: 5.2-7.2 at 60 cps; dissipation factor: 0.02-0.07 at 60 cps; arc resistance: 140-180 sec), 2) resistance to heat (ASTM heat distortion point under 264-psi load: 350-400 F), and excellent dimensional stability. Dimensional accuracy in moldings is readily obtainable because of uniform, low shrinkage (0.012-0.001 in. per in.). Price is about 34-53¢ per lb.

Alkyds are available as:

1. Granular, mineral-filled compounds for automatic compression molding at low pressures and short cycles. Such compounds are used for vacuum tube bases, auto ignition parts and power circuit insulation.

2. Mineral-filled putty for low pressure molding around delicate inserts. Typical uses include insulation for capacitors and resistors, and toroid and pie-wound coils.

3. Glass-reinforced, mat-like compounds for compression molding of high impact parts. Typical uses include mobile antenna mounts, computer components and switchgear.

Diallyl phthalate

DAP (diallyl phthalate) molding

Matched metal molding Usually used for molding reinforced plastics. Reinforcing mat or cloth (often in preform shape) is laid in open mold, liquid resin is poured over reinforcement, mold is closed and heated to cure material.

Premix molding Economical method in which resin formulation and reinforcement is premixed in dough-type mixer prior to molding in matched metal dies.

Reinforced plastics molding Broad term referring to any of variety of methods (such as high or low pressure laminating or premix molding) of combining a resin (usually thermosetting, but in some cases thermoplastic) with a reinforcing material. Most commonly used to refer to glass-reinforced polyester or epoxy low pressure laminate. Reinforcements may consist of glass, asbestos, cellulose, sisal, cord and metal, in the form of chopped fiber or roving, woven or nonwoven fabrics and felts, or papers. Synthetic organic fibers also used.

High pressure laminating Material usually in form of reinforcing cloth, web or mat preimpregnated with thermosetting resin and partially polymerized. This "prepreg" material then molded, under pressures usually greater than 1000 psi, into sheet, rod, tube or other shape. Sheet, rod and tube forms usually referred to as industrial thermosetting laminates. Specifications and standards for such materials developed by NEMA (National Electrical Manufacturers' Assn.).

Low pressure laminating Broad term referring to a variety of methods of fabricating reinforced plastics shapes at molding pressures of less than 1000 psi. Can be used to make extremely large shapes. One of most common methods is hand lay-up technique, in which layers of reinforcing materials (cloth or mat) are individually impregnated with resin by hand and fitted to male or female mold. Preimpregnated materials may also be used. Molding may be allowed to cure with no pressure, or variety of methods may be used to apply low pressures during cure. Among the most common techniques: vacuum bag, pressure bag and matched metal molds. Continuous sheet can be produced by passing material through heated rolls.

Filament winding Reinforcing fiber or roving (usually glass) is passed through resin bath and wound on mold, which is turned in lathe-like device. After sufficient thickness is built up, resin usually oven-cured. Shapes may be cylindrical, spherical or modifications thereof.

Spray molding Term coined here to describe recently developed method of spraying resin and chopped fiber reinforcement against mold to economically form large shapes such as boat hulls. Spray device consists of two guns, one to spray resin, the other to chop and blow fibrous reinforcement. After spraying, layer is rolled smooth on mold with roller. (See sections on "Polyesters" and "Epoxies.")

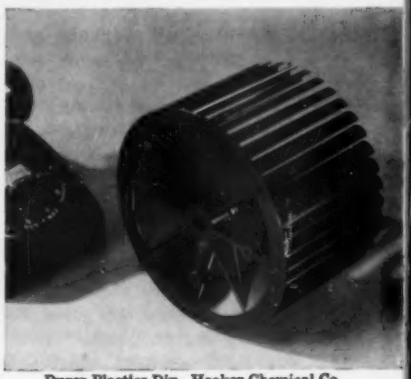
Casting Liquid monomer system (including monomer, fillers, hardeners and catalysts) is cast in mold to desired shape and cured. Differs from molding only in that no pressure is used. Commonly used for potting and encapsulation. Centrifugal casting, usually used to form pipe, tanks and other cylindrical shapes, makes use of centrifugal force to force resin to completely saturate reinforcing cloth or mat.

Postforming Method of forming industrial thermosetting laminates after laminates have been cured. Binder resins in certain so-called postformable grades of laminates have been modified to provide degree of thermoplastic behavior. Reinforcement is of type that provides degree of stretch. Laminates can be postformed into relatively complex shapes by flash heating and forming. Forming of vulcanized fibre sheet not termed postforming, but is similar; fibre is softened with water rather than heat.

Thermosets are often used to provide durable, strong, economical parts

Celanese Corp. of America

Polyester premix *molding materials make economical, intricately shaped parts with relatively good strength characteristics. Here are knobs, ferrules, housings and an impeller.*



Dures Plastics Div., Hooker Chemical Co.

General purpose phenolic *molding material is used for high impact, structural strength, as well as moderate chemical resistance in this blower wheel.*

. . . large, reinforced plastics structural parts . . .

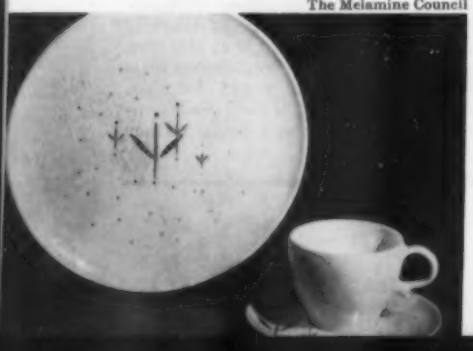
Celanese Corp. of America

Glass-reinforced polyester *laminates form a strong, translucent, lightweight body for this trailer truck.*

. . . hard, decorative parts . . .

Melamine *forms hard, decorative surfaces for plastics dinnerware. Heat resistance is also relatively good.*

The Melamine Council



compounds are based on polymers of DAP. Notable properties include: 1) good dielectric properties which are relatively unaffected by moisture (dielectric strength: 350-400 v per mil; dielectric constant: 3.5-3.8 at 60 cps; dissipation factor: 0.026 at 60 cps; arc resistance: 85-190 sec), 2) low moisture absorption (0.1-0.4% in 48 hr at 122 F), 3) resistance to heat (ASTM heat distortion point under 264-psi load: 250-350 F; maximum continuous service temperature: as high as 500 F for some types), and 4) excellent dimensional stability. Mold shrinkage is about 0.01-0.005 in. per in.

DAP compounds are available with a variety of fillers, including cellulose, asbestos, glass, acrylic or polyester fiber, to provide specific ranges of properties. Compounds are used for a variety of electrical and electronic parts, such as connectors, rotors and switches, where dielectric characteristics must be retained after exposure to moisture.

Silicones

Silicones are unique among plastics in that they are semi-organic, i.e., the molecular "spine" of the molecule has alternating silicon and oxygen atoms, with organic groups attached to the silicon. Primary attributes of silicone resins are: 1) resistance to heat (maximum continuous service temperature: 400-550 F; ASTM 264-psi heat distortion points of over 900 F are obtainable in some materials), 2) high dielectric properties (dielectric strength: 300-400 v per mil; dielectric constant: 4.0-5.0 at 60 cps; arc resistance: 300-420 sec), and 3) low moisture absorption (0.3-0.5% in 48 hr). They are suitable for 360 F class (formerly Class H) insulation. Mechanical strength is usually not as high as in other structural thermosetting resin systems, but strength is retained exceptionally well at elevated temperatures.

Silicones are available as liquid laminating and casting resins, reinforced molding compounds, dry pow-

der for rigid foams, and high pressure laminates.

Liquid resins are used for potting and encapsulation of electrical or electronic components that must operate at high temperatures. Laminated with glass cloth, mat or other types of reinforcement, they provide good strength particularly on exposure to heat (flexural strength: 43,000 psi at 77 F, 40,000 psi after 200 hr at 500 F; modulus in flexure: 2.8 million psi both at 77 F and after 200 hr at 500 F; tensile strength: 40,500 psi at 77 F, 30,500 psi after 200 hr at 500 F). They also provide excellent dielectric properties, which are relatively unaffected by heat.

Laminates are used for such applications as aircraft radomes and ductwork, thermal and arc barriers, and covers and cases for high frequency equipment.

Reinforced molding compounds are available with fillers such as minerals and glass fibers. They provide tensile strengths of 3500-5000 psi, flexural strengths of 6000-11,000 psi, and modulus in flexure values of about 1 million psi. They are primarily used for 360 F class (formerly Class H) insulation. Typical uses include terminal boards, coil forms, connector plugs and switches which must withstand heat.

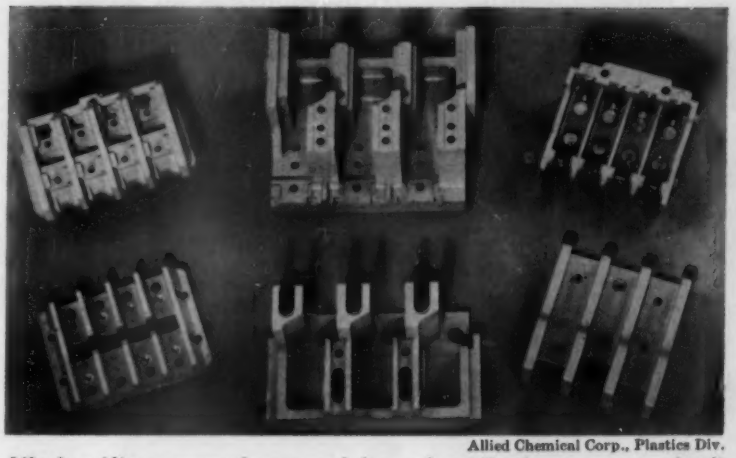
High pressure laminates with silicone binders are classified by NEMA as industrial thermosetting laminate grade G-6, glass-base, 360 F class insulating stock; and G-7, glass-base, 360 F class insulation with superior dielectric strength perpendicular to lamination.

Ureas

Urea formaldehyde, an amino plastic, is usually used as a molding compound. It is relatively inexpensive (19-33¢ per lb) and can be produced in almost any color with high translucency and light fastness. Ureas provide hard, scratch resistant surfaces (Rockwell M115-120), moderate strengths (flexural strength: 10,000-16,000 psi) and moderate electrical properties (dielectric strength: 330-370 v per mil; dielectric constant: 7.7-7.9 at 60 cps; arc resistance: 80-130 sec). They are completely resistant to organic solvents. Maximum continuous service temperature is limited to about 170 F, and moisture absorption is relatively high (0.4-0.8% in 24 hr). Urea compounds are available filled with alpha cellulose, cellulose and woodflour.

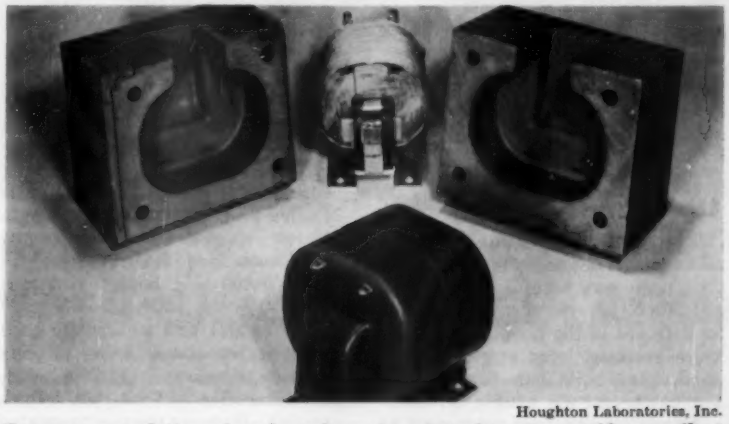
Typical applications include radio

. . . high dielectric properties . . .



Allied Chemical Corp., Plastics Div.

***Alkyd** molding compounds are used for such applications as power circuit insulation, where high arc resistance and insulation resistance are critical.*



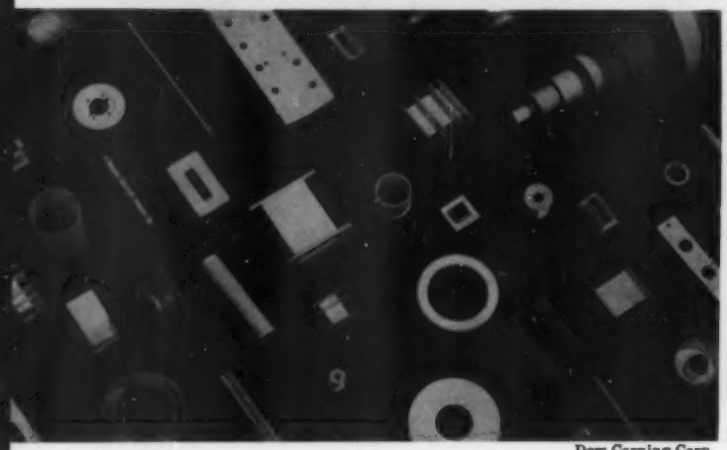
Houghton Laboratories, Inc.

***Epoxy** encapsulation of such equipment as transformers provides excellent dielectric properties, as well as protection against environmental conditions such as moisture and thermal shock. In this case metal-filled epoxy was used for the mold in which the small transformer was encapsulated.*

***Urea** moldings are used for the toggles and switch handles on industrial and residential circuit breakers. Ureas have relatively good dielectric strength and minimal arc tracking, and they can be colored.*

Allied Chemical Corp.

. . . high temperature electrical or mechanical properties



Dow Corning Corp.

***Silicone** electrical or mechanical components can be produced by laminating, casting, molding or machining. They provide excellent resistance to temperatures up to about 550 F.*

Raybestos-Manhattan, Inc.

***Phenolic** with asbestos reinforcement has a low ablation rate. This prototype missile fin has been subjected to speeds of Mach 7.*

cabinets, closures, cosmetic containers, electric mixer housings, and electrical parts such as wiring devices.

Urethanes

Urethanes are reaction products of an isocyanate and a reactive resin. The resin may be of a polyester or polyether type. Most urethanes used to date are in the form of foams or, more recently, solid elastomers. A solid, hard resin can be produced, but has been little used.

Foams may be rigid, semi-rigid or flexible, and can be foamed-in-place to fill any shape cavity.

The bulk of the rigid foams have been of the polyester type, and of closed cell structure. They are used as thermal insulation, and for lightweight structural strength (as in cores for sandwich panels), electrical insulation and buoyancy.

Semi-rigid foams, usually of the polyester type, have resilience on the order of 10-30%, and combine open with closed cell structure. They are used for thermal insulation, where a degree of resilience is required, and as energy absorption devices.

Flexible foams may be of polyester or polyether type, the major difference between the two being in their hysteresis. Polyethers are most widely used for cushioning applications in aircraft and auto seats. Polyesters are used for energy absorption devices such as auto crash pads.

Vulcanized fibre

Vulcanized fibre is an inexpensive, hard, horny-like material consisting of partially regenerated cellulose. It is available as sheet, rod and tube. Notable properties include: strength at low weight (tensile strength: 6000-12,000 psi; flexural strength: 12,000-20,000 psi; impact strength: 4-8 ft-lb per in. notch; density: 0.04 lb per cu in.) and moderately good dielectric properties. Fibre is quite sensitive to moisture (55-66% in 24-hr immersion of 1/8-in. thick sample). However resin-impregnated grades are available for improved moisture resistance.

NEMA now classifies 13 grades of vulcanized fibre for different end-uses. Typical applications include trunks, cases, wastebaskets, mail boxes, gears, cams, bushings, grommets, switch handles, terminal blocks, armature slot insulation and end laminations, field coil insulation, arc shields, and formed slot wedges.

Acknowledgments:

The author would particularly like to thank the following for their help in reviewing the manuscript: Dr. R. Greene, Allied Chemical Corp.; Dr. W. D. Paist, Celanese Corp. of America; G. T. Thayer, Dow Chemical Co.; Dr. R. Peterson, E. I. du Pont de Nemours & Co., Inc.; R. O. Hill, Eastman Chemical Products, Inc.; and Dr. C. D. McCleary, Dr. R. G. Nelb, I. Mankowich, and R. L. Knapp, Naugatuck Chemical Co., Div. of U. S. Rubber Co.

The assistance of personnel and literature of the following companies and associations is also gratefully acknowledged:

Acme Resin Corp.
Allied Chemical Corp., Plastics and Coal Chemicals Div.
American Cyanamid Co., Plastics and Resins Div.
Atlas Powder Co.
Booty Resineers Div., American-Marietta Co.
Celanese Corp. of America
Dow Chemical Co.
Dow Corning Corp.
E. I. du Pont de Nemours & Co., Inc.
Eastman Chemical Products, Inc.
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Polymer Corp. of Penna.
Raybestos-Manhattan, Inc., Reinforced Plastics Dept.
Rohm & Haas Co.
Shell Chemical Corp.
Society of the Plastics Industry, Inc.
Spencer Chemical Co.
Union Carbide Chemicals Co., Div. of Union Carbide Corp.

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first in silicones

Dow Corning

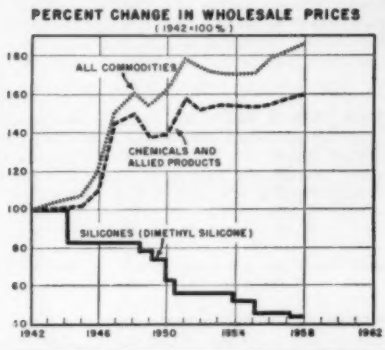
SILICONE NEWS

for design and development engineers • No. 59

BUCKING THE TREND

Designers who investigate will be pleasantly surprised at the way the prices of Dow Corning silicone products have remained level or even declined while most material costs have been going steadily upward. A typical example is Silastic® LS-53, the Dow Corning fluorosilicone rubber. Just reduced in price for the third time, it now costs 40% less than it did in 1956.

Unusually resistant to fuels, oils, chemicals and high and low temperatures, this fluorosilicone rubber has become increasingly popular for O-rings, seals, gaskets and hoses. It's the growing demand for LS-53, in fact, with both military and non-military users, that has resulted in production economies which Dow Corning has passed on in the form of price reductions now totalling 40%. *(Cont. Pg. 2)*



BOOST PLANE'S CAPABILITY WITH SILICONE INSULATION

An excellent example of how silicone electrical insulation reduces size and weight, while solving high temperature problems, is the a-c generator on Convair's supersonic F-102A.

The evolution of this generator typifies industry's use of new materials to meet the light-weight and thermal demands of equipment on military aircraft. Built by Jack & Heintz, Cleveland, early models were insulated with Class B materials. In newer, supersonic aircraft like the F-102A, however, the generator is cooled with an air stream in the range of 120 C (248 F) . . . far beyond the ambient temperature allowances permissible for even the best Class B insulating materials.

Jack & Heintz solved this jet-age problem by re-designing the generator to incorporate heat-stable Dow Corning silicone insulation. Insulated with silicones, the new generator provides equivalent performance at the much higher temperatures . . . and it weighs 9 pounds less than its predecessor!

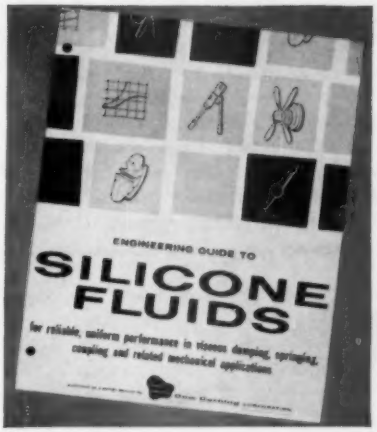
How important is this weight saving? Applying a weight factor associated with aircraft like the F-102A, these 9 pounds reduce take-off weight by 150 pounds, a very significant factor in boosting an aircraft's speed, range and altitude capabilities . . . or in allowing for additional instrumentation or payload. *No. 604*

Valuable Reference for Designers

Advance research and development engineers and maintenance equipment designers have found this eight-page, file-size guide a practical aid—a valuable "must" reference. It is a unique compilation of information essential to selecting the most suitable silicone fluid medium when designing for reliable, uniform performance.

Typical applications cited show how silicone fluids are used to advantage in damping, springing, coupling and related mechanical applications. Tables, graphs and figures complement detailed information about the properties that enable silicone fluids to increase efficiency of existing designs and make possible new design changes.

For your free copy, encircle ..... *No. 605*


ENGINEERING GUIDE TO
SILICONE FLUIDS
for reliable, uniform performance in viscous damping, springing, coupling and related mechanical applications

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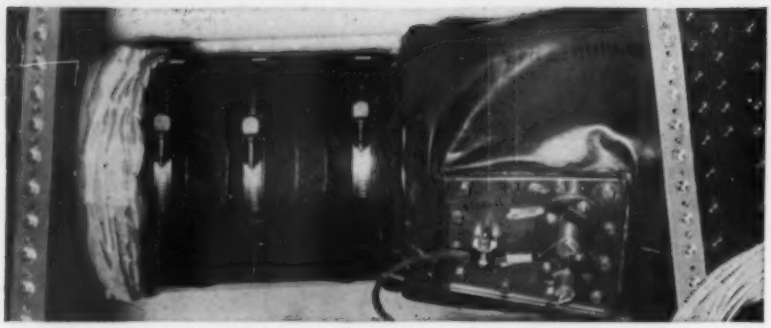

NEW FORMED-IN-PLACE HIGH TEMPERATURE SEALS

Re-usuable seals for high temperature service are easy to make with Silastic®, the Dow Corning silicone rubber. Here's how it's done on the cabin heater and de-icer ducts of DC-6 and DC-7 aircraft.

A Silastic paste is applied directly to the edges of the switch plate opening of the duct. When the switch plate is put in place, the assembled parts act as the mold forming the silicone rubber gasket.

Cured in place by operating temperatures, the Silastic paste forms a resilient, custom-fit gasket that maintains a permanently tight seal regardless of vibration or internal pressure. What's more, the silicone rubber gaskets are unaffected by the 350 F air-stream passing through the ducts, and can be counted on to keep a positive seal even if the unit overheats and temperatures rise to 500 F.

If you need resilient, high temperature gaskets in quantities too limited to justify ready-made gaskets, do as Douglas does . . . specify Silastic paste rather than a part number. If you need quantities, remember, more than 100 rubber companies supply moldings, extrusions, ducting and hose, tubing, coated fabrics, tapes, wire and cable, O-rings, gaskets, seals, rolls and sponged parts made from Silastic, the Dow Corning silicone rubber. *No. 606*

TREND *(Continued)*

Now it makes even more sense than ever before to investigate silicones in seeking economical solutions to design problems. All Dow Corning Silicones, not just Silastic LS-53, have followed downward price trends with increasing use and demand —despite a rising commodity index! *No. 607*

new literature and technical data on silicones

FAST ENGINEERING AID. In just 30 minutes or less Silastic RTV 502, the new Dow Corning room temperature vulcanizing silicone rubber, sets into molds for prototypes and models, or for actual rubbery parts. On-the-job designs and testing can be done easier, faster. Typical properties and additional applications are listed in helpful data sheet. *No. 608*

PAINTS LAST LONGER . . . IF they contain silicones. A 4-page brochure explains the difference between modified, straight silicone paints, and "siliconized" paints. It describes some of the more common applications and the maintenance-saving and extended performance life of silicone based paints, and also contains a listing of manufacturers. *No. 609*

SYL-OFF SAVES—Package designs for sticky products can have functional freedom as well as attractiveness through the use of Syl-off coated papers, paperboard, liners, wrappers, and other packaging materials. These Dow Corning silicone paper coatings are now available from most paper companies and give the fastest, easiest release possible for products ranging from asphalt to candy, or adhesives to unvulcanized rubber. A brochure reviews more of the properties and uses for Syl-off. *No. 610*

STICK WITH A BOND that does the best job. Dow Corning silicone primers and adhesives for silicone rubber are used with metals, plastics, glass, ceramics, and many other materials where a good bonding surface is desired. Designing around silicone primers and adhesives can produce a bond strength as strong as the tear strength of the silicone rubber itself. Two concise data sheets give full information. *No. 611*

DESIGN TIP OF THE MONTH—Take a look at silicone-glass laminates. You'll be surprised at their versatility and usefulness, whether you design for consumer or industrial manufactured products. Examples of many applications and a comprehensive table of physical and dielectric engineering properties are contained in this 4-page brochure . . . . . *No. 612*

NEW 1959 REFERENCE GUIDE to Dow Corning silicone products is now available. This file size brochure contains indexed sections covering silicone fluids, dielectrics, protective coatings, release agents, water repellents and Silastic, the Dow Corning silicone rubber. A handy rapid reference to the specific silicone product that will solve your design problems. *No. 613*

Dow Corning Corporation, Dept. 7014, Midland, Michigan

Please send me: 604 605 606 607 608 609 610 611 612 613

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TITLE _____

COMPANY _____

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Dow Corning CORPORATION
MIDLAND, MICHIGAN

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FILE FACTS

Properties and Uses of Electroplates

Coating ↓	Physical Properties			Corrosion Resistance		Soldering Properties		Uses[a]
	Ther Cond, Btu/hr/sq ft/°F/ft	Elec Res, microhm-cm	Reflectance When Polished (5000 A), %	Atmosphere, 10^{-6} ipy	Sea Water, 10^{-6} ipy	As Plated	After 192 Hr Salt Spray	
Aluminum	122	2.8	—	—	20-3400	—	—	e
Antimony	10.2	41.7	50	—	—	—	—	c, d
Arsenic	—	35	—	—	—	—	—	D
Bismuth	4.6	119	—	—	—	—	—	c
Cadmium	5.3	7.5	—	250-510	700	Good	Poor	C, d, w
Chromium	—	14-66	—	—	—	Poor	Poor	c, D, e, R, W
Cobalt	—	6.2	—	—	—	—	—	c, e, r
Copper	222	3-8	44	54-464	2000	Good	—	c, d, E
Gold	169	2.4	47	—	—	Good	Good	c, D, e
Indium	—	8.4	—	—	—	Good	—	c, d, W
Iron	38.7	10	0.55	—	—	Fair	Poor	e, R, w
Lead	20.1	22.6	—	9-27	400-600	—	—	C, e, w
Magnesium	91	4.6	0.72	—	10,000-80,000	—	—	Experimental
Manganese	—	5	—	—	—	—	—	Experimental
Molybdenum	83.8	5.7	46	—	—	—	—	Experimental
Nickel	34.4	7.4-10.8	61	1-160	300-1000	Good	Poor	C, D, E, R, W
Palladium	40.6	11	—	—	—	—	—	c, D
Platinum	40.2	10	58	—	—	—	—	c, D
Rhenium	—	21	—	—	—	—	—	d
Rhodium	50.9	4.7	76	—	—	—	—	c, D
Selenium	—	12	—	—	—	—	—	Rectifiers
Silver	244	1.6	91	—	40	—	—	C, D, e, w
Tin	36.3	11.5	—	72-320	30-90	Good	Poor	C, e, w
Titanium	—	3.2	—	—	—	—	—	Experimental
Tungsten	84.7	5.5	0.49	—	—	Good	Poor	Experimental
Zinc	64.2	5.8	55	8-210	1000-6000	—	—	C, d
Zirconium	—	41	—	—	—	—	—	Experimental
Cobalt-Nickel	—	—	—	—	—	—	—	Magnetic
Copper-Tin	—	—	—	—	—	—	—	c, D, w
Copper-Zinc	—	—	—	—	—	—	—	c, D
Lead-Tin	—	—	—	—	—	Good	—	c, w
Nickel-Tin	—	15-118	—	—	—	—	—	C, D
Phosphorous-Nickel-Cobalt	—	10-118	—	—	—	—	—	C, d, e, w
Tin-Zinc	—	—	—	—	—	Good	Poor	C
Tungsten-Nickel-Cobalt-Iron	—	—	—	—	—	—	—	C, e, r, w

[a] C = frequently for corrosion protection; e = infrequently for corrosion protection; D = frequently for decoration; d = infrequently for decoration; E = frequently for electroforming; e = infrequently for electroforming; R = frequently for reclaiming parts; r = infrequently for reclaiming parts; W = frequently for wear resistance; w = infrequently for wear resistance

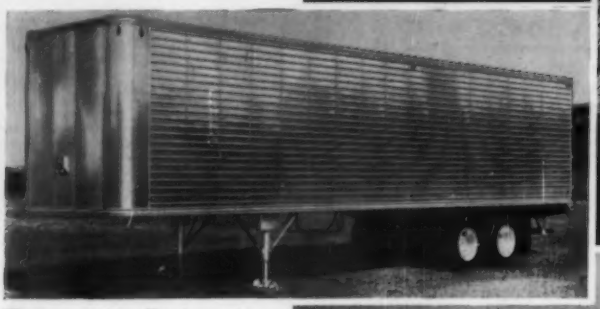
Data courtesy Engineering Dept., U. S. Naval Ordnance Test Station, Inyorken, Calif.

For more information, circle No. 510

When aluminum is part of your product . . .

Appliances

Building Materials



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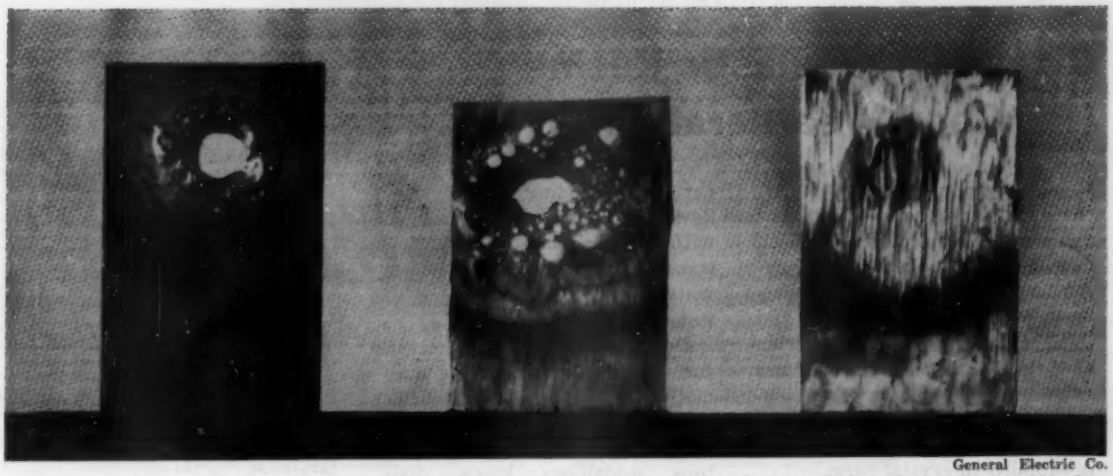
For more information, turn to Reader Service card, circle No. 522

What's new IN MATERIALS

Edited by
John A. Mock



General Electric Co.

Hot flame of more than 5000 F *melted and burned through steel panel and glass-reinforced plastics panel in less than 40 sec. Quartz-reinforced plastics panel withstood the flame and retained its structural strength after exposure for 40 sec.*

General Electric Co.

Thread and cloth *made of fused quartz are said to hold their tensile strengths at far higher temperatures than any other textile reinforcement.*

Quartz-Reinforced Plastics Keep Their Strength at 5000 F

■ Pure fused quartz—for its weight, one of the most heat resistant materials available—has been successfully woven into thread and cloth on textile equipment. Tests indicate quartz thread and cloth will withstand temperatures over 5000 F.

The thread and method of fabrication were developed by General Electric Co., Lamp Glass Dept., Nela Park, Cleveland 12, Ohio. The company says the price of the material will probably be many times that of ordinary fiber.

Quartz-reinforced plastics are one of a number of promising uses for the new material. In fact, the Missile Div. of Haveg Industries, Inc., 900 Greenbank Rd., Wilmington 8, Del., is now molding a combination of pure quartz fibers and thermosetting plastic resins into missile parts. These plastics parts are said to withstand temperatures far above the melting point of resin-glass and resin-asbestos combinations currently being used for insulation in missile structures. Haveg's quartz-reinforced plastic has been given the trade name Planeton Q.

(continued on p 124)

GE engineers say that in missile applications where quartz-reinforced plastics replace metal, there is a potential weight reduction of more than 10 to 1.

Other uses foreseen by GE engineers for quartz thread and cloth include filters, thin insulations in flexible and irregular form, safety devices, and heat resistant structural forms for machinery and construction.

Properties

According to GE, quartz thread has high purity, low thermal conductivity, extremely low coefficient of expansion, high softening point and high viscosity. Quartz thread has excellent resistance to weathering because of its chemical inertness. However, the chemical inertness of the material limits the possibility of dyeing or staining quartz cloth.

Clear Thermoplastic Resin Has Good Weatherability

■ An extremely clear thermoplastic resin, a copolymer of styrene and methyl methacrylate, has been developed for applications requiring crystal clarity, heat resistance, outdoor weatherability and light stability. Designated Zerlon 150, the thermoplastic molds and extrudes with relative ease, comparing favorably with heat resistant polystyrene formulations. It is supplied in crystal form.

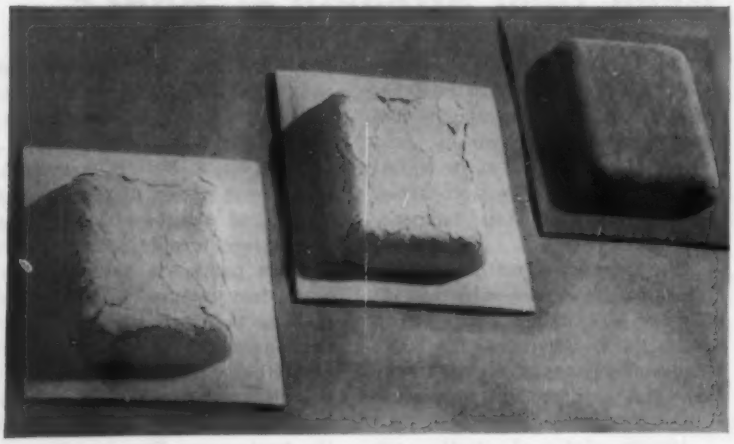
Introduced by Dow Chemical Co., Midland, Mich., the material is the first member of a new family of plastics molding materials. The material sells for 49 to 50½¢ per lb, depending on quantity. Zerlon 150 is expected to compete with a wide variety of present transparent thermoplastic molding materials.

Potential uses

Dow thinks the biggest markets for the product lie in the automotive, appliance and sign fields. Typical uses might be molded and extruded parts such as horn buttons, medallions, knobs, dials, escutcheons for major appliances, light fixtures, decorative items and boat windshields. Outdoor uses, such as signs, will be a major market for Zerlon, Dow believes.

PROPERTIES OF ZERLON 150

PHYSICAL PROPERTIES	
Specific Gravity	1.14
Flammability, in./min	1.7
Mold Shrinkage, in./in.	0.004
Refractive Index, N_D	1.533
Luminous Transmittance, %	91
Water Absorption (24 hr), %	0.2
Coef of Ther Exp, per °F	3.7×10^{-5}
MECHANICAL PROPERTIES	
Tensile Strength, psi	9000
Elongation, %	5
Tensile Modulus, psi	4.7×10^5
Flexural Strength, psi	17,600
Flexural Modulus, psi	5.1×10^5
Izod Impact Strength, ft-lb/in.	0.4
Rockwell Hardness	M78
Heat Distortion Temp (264 psi), F	205
ELECTRICAL PROPERTIES	
Dielectric Constant	
10^3 Cps	3.13
10^6 Cps	2.81
Dissipation Factor	
10^3 Cps	0.0246
10^6 Cps	0.0193



Stretchable laminated paper—As shown here forming operations do not crack a plastics-laminated cross-creped kraft paper (right) as they do machine creped-kraft (left) and extensible kraft (center). The laminated paper, called X-Crepe, is said to stretch as much as 60% during forming operations without breaking.

Cross-creped kraft paper, discussed in a previous issue of this magazine (see M/DE, Nov '57, p 138), as well as laminated cross-creped kraft, is now commercially available from Cincinnati Industries, Inc., 500 Station Ave., Cincinnati 15, Ohio.

The laminated paper is supplied as a single ply or as a multi-ply material. The paper is presently laminated with polystyrene but other plastics are being considered.

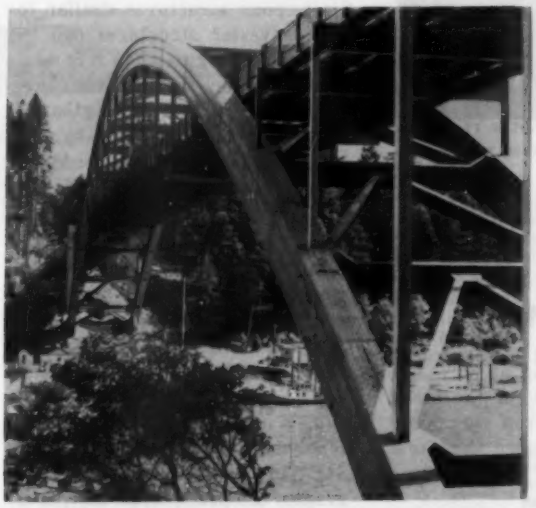
High Strength, Low Alloy Steels for Special Uses

■ Three high strength, low alloy steels, each offering a special combination of properties, have been developed by Kaiser Steel Corp. According to Kaiser, the steels are characterized by good workability, superior ductility, high yield strength, excellent weldability, exceptional toughness, improved corrosion resistance, and resistance to abrasion and deformation. Cost information is unavailable. Special properties and typical applications of each steel are described below.

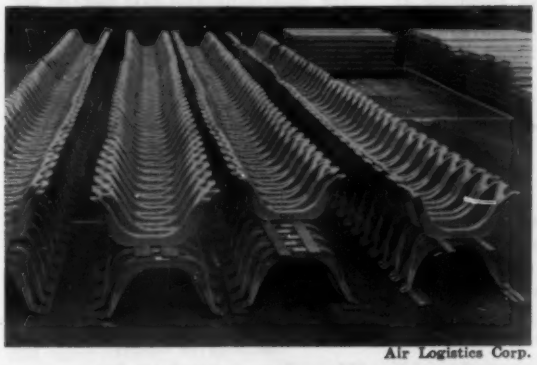
PROPERTIES OF KAISALOY HIGH STRENGTH, LOW ALLOY STEELS

Type →	Kaisaloy 1	Kaisaloy 2	Kaisaloy 3
COMPOSITION, %	C 0.11, Mn 0.63, Si 0.48, Cu 0.27, Ni 0.27, Cr 0.18, Mo 0.06, V 0.08, Ti 0.008	C 0.09, Mn 0.38, Si 0.36, Cu 0.14, Ni 0.25, Cr 0.10, Mo 0.04, V 0.06, Ti 0.010	C 0.21, Mn 1.31, Si 0.25, Cu 0.25, Ni 0.03, Cr 0.10, Mo 0.03, V 0.10, Ti 0.010
MECHANICAL PROPERTIES			
Mod of Elast, 10^6 psi	28-29	—	28-29
Ten Str, 1000 psi	70	60	90
Yld Str (0.2% offset), 1000 psi	50	45	60
Elong (in 2 in.), %	22	25	15[a]
Compr Yld Str, 1000 psi	70	—	90
Shear Str, 1000 psi	52	—	67
AVAILABLE FORMS	Sheet, plate, bar, structural shapes	Plate, sheet, strip	Plate, bar, structural shapes

[a] In 8 in.



Kaisaloy 1 (regular grade)—Although primarily designed for high yield and tensile strengths, this alloy offers improved corrosion resistance (as compared to carbon steel) and excellent weldability. In addition, the alloy has good abrasion resistance and impact and fatigue properties, and is suggested for structural applications where weight reductions and corrosion resistance are major considerations. *Left*—bridge.



Air Logistics Corp.

Kaisaloy 2 (forming grade)—This alloy is useful when bend requirements are restrictive or when limited forming must be done to produce a finished part with relatively high strength. It is especially suited for parts which require a higher degree of ductility than can be obtained with Kaisaloy 1. According to Kaiser, the high ductility is obtained by relaxing the high yield and tensile values of Kaisaloy 1. However, cold working may result in even higher strengths. *Left*—guided missile parts.

Kaisaloy 3 (wear resistant grade)—This alloy differs from the other two in that it offers extra high strength, exceptional wear resistance and excellent weldability. Its cold formability, however, is limited. The alloy is recommended for applications requiring rugged strength and wear resistance. It is said to fill the gap between the hard-to-weld medium carbon, abrasion resistant steels and the readily weldable, low strength, low-wear-resistance carbon steels. *Left*—dump barge.

Union Carbide Plastics Co.

***Spraying epoxy resin** on a plastics die with a newly developed spray gun.*

New Resins, Sheets, Films Announced at Plastics Show

■ Many new developments in plastics materials were announced at the 8th National Plastics Exposition held recently in Chicago. (For more information on the show, see M/DE, Jan '59, p 178.) Five developments of particular interest to designers and engineers were:

1. Four alkyd resins

Excellent retention of insulation resistance after exposure to moisture and heat is the major benefit offered by four new alkyd molding compounds introduced by Allied Chemical Corp., Plastics & Coal Chemicals Div., 40 Rector St., New York 6.

The four compounds are: 1) a glass fiber-filled impact-grade molding compound (PM-14), 2) two free-flowing granular types—one for plunger molding (PM-15), the other for fast-cure compression molding (PM-17), and 3) a putty-type molding compound (PM-18). Properties of the four resins are given in Table 1.

Insulation resistance values of 25,000-30,000 megohms (after one-day exposure to 95% RH and 160 F) drop to 15,000-20,000 megohms for two of the compounds after 60 days' aging at 95% RH and 160 F. Values for the other two compounds drop to 5000-10,000 megohms under the same conditions.

2. Epoxy spray gun

Rapid and uniform spraying of quick-curing epoxy resin systems (with or without chopped glass reinforcement) can now be done with a new epoxy spray gun. The new concept in epoxy spray coating was announced by Union Carbide Plastics Co., Div. of Union Carbide Corp., 30 E. 42nd St., New York 17. The gun is manufactured by A. Gusmer, Inc., Woodbridge, N. J.

The gun is designed to meter the resin and catalyst so that mixing takes place within the barrel of the gun, and the mixture is sprayed under positive pressure. Glass-epoxy structures similar to glass-polyester structures can be made with the gun when it is used in conjunction with a glass chopping gun. Higher strengths of epoxy structures are said to permit reduction in section thickness of such products as boat hulls.

3. Colored phenolic compound

A colored molding compound, a copolymer of phenolic and melamine resins, combines the colorability of melamine with the lower cost and moldability of phenolics. Announced by Plastics Engineering Co., 1607 Geele Ave., Sheboygan, Wis., the melamine-phenolic copolymer compound costs about 34¢ per lb in general purpose grades, compared with 45¢ per lb for melamine and 20¢ per lb for phenolic.

(continued on p 128)

MORE WHAT'S NEW IN MATERIALS

Composite electroplate protects molybdenum... 130
Five-ply strip for vacuum tube anodes.... 132
TFE, polyurethane and silicone rubber tapes... 134
Brazed wire cloth..... 136
Copper alloy rod..... 138
Rubber-like adhesive 140
Filled TFE performs well in liquid nitrogen..... 142
Epoxy electrical parts.... 144
Finish for aluminum..... 146
TFE o-rings 146
Aluminum alloy 7079 available as plate..... 148
Two PVC plastics 150
Clear anodize applied quickly to magnesium.. 152
Phenolic laminates 155
High strength steels..... 158
Synthetic quartz 158
Urethane insulation 160
Sintered glass fuses directly to copper..... 160
Two electroplates for zinc die castings..... 162
Asbestos-filled plastic is strong at 500 F..... 164
Nickel-base alloy sold as sheet, bar, castings.. 166
Ferromagnetic parts 168
Vibrating matter 168
Leaded steel tubing..... 170
Phenolic-fiberglass 172
Silicone-modified resin.... 174
Laminated glass TV tube 174
Other news 176

For more information, circle No. 504 ➤

Now... because of new

and expanded product lines,

Swedlow Plastics Company

announces a change in name to...

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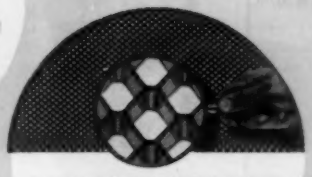
(EFFECTIVE FEBRUARY 1, 1960)

STRETCHED AND MONOLITHIC PLASTIC GLAZING for aircraft windows and enclosures. Optically polished, tough, light weight.



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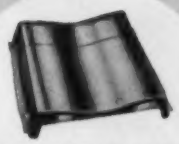
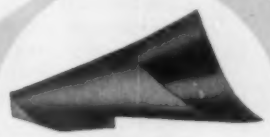


HIGH TEMPERATURE REINFORCED PLASTIC LAMINATES for sheeting and contoured parts in missiles and aircraft.



PRIMARY SOURCE FOR CONTINUOUS AND PRESS MADE LAMINATES for aircraft and industrial uses—fibre glass, cotton, nylon, etc.

KEVINITE FLEXIBLE, DECORATIVE LAMINATE. An all-paper, polyester, continuous laminate, available in many color and design combinations.

Swedlow has long been well known as a leader in the development and fabrication of high quality Plastic Glazing for aircraft. Excellence in this field has resulted in demands for the same type of development and craftsmanship in additional products of fine quality, involving metals and many other materials.

High temperature Welded Honeycomb Core in stainless steel and super alloys has become a very important part of our business, along with Aluminum Honeycomb Core, and the volume of these light weight, strong structural materials is growing rapidly to meet the increasing needs of aircraft, missile and other industries.

Swedlow products also include a wide variety of high heat-resistant reinforced plastics, utilizing fibre glass with silicone, phenolic and epoxy binders and metalized for extra heat protection.

This diversification and expansion makes the change to a more inclusive name desirable. In all of its products, the company will continue to adhere to the highest standards of quality and workmanship in the future.

SWEDLOW Inc.

LOS ANGELES 22, CALIFORNIA / YOUNGSTOWN 9, OHIO

PLEASE REFER TO DEPT. 18

STRAITS TIN REPORT

New developments in the production, marketing and uses of tin

MALAYAN TIN BUREAU

☆

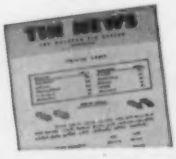
Five times cheaper than stainless steel. That's what the British dairy industry reports about seamless tinned steel milk cans. It finds that a heavy tin coating gives a good adherent finish, provides excellent corrosion resistance, is completely nontoxic, and does not in any way affect the flavor or the nutritive value of the milk.

★

The increasingly important role of tin in this age of the jet and missile is again confirmed. A tin-zinc alloy is being used to plate jet aircraft hydraulic brake parts and thus prevent corrosion. The alloy is 75% tin and 25% zinc.

☆

Another new product is available in the popular aerosol cans. It is Freon, an odorless, colorless gas normally used as a refrigerating agent. The aerosol Freon bomb will double as your personal, portable tire pump and fire extinguisher. It can be used to inflate the average tire with 22 pounds of pressure in just 6 seconds. It kills fires by depriving the flames of oxygen and lowering the surrounding temperature.



Ask us to send you TIN NEWS, a monthly letter. It will keep you posted on tin supply, prices, new uses and applications.

The Malayan Tin Bureau

Dept. 24B, 1028 Connecticut Ave., Washington 6, D. C.

For more information, circle No. 498

What's new IN MATERIALS

TABLE 1—PROPERTIES OF ALKYD RESINS

Type →	PM-14	PM-15	PM-17	PM-18
PHYSICAL PROPERTIES				
Specific Gravity	1.80	2.00	2.10	2.00
Water Absorption (24 hr), %	0.075	0.050	0.060	0.080
Flammability, in./min	Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing
Max Heat Resistance, F				
Long Periods	300	350	300	300
Short Periods	400	425	375	375
MECHANICAL PROPERTIES				
Notched Izod Impact Strength, ft-lb/in.	4	0.30	0.30	0.30
Tensile Strength, 1000 psi	7	3	4	4
Compressive Strength, 1000 psi	22	19	15	21
Flexural Strength, 1000 psi	12	6	6	9
Modulus of Elasticity, psi	2.0×10^6	2.1×10^6	2.1×10^6	2.1×10^6
Barcol Hardness	65	60	58	58
Heat Distortion Temp (264 psi), F	400	350	300	300
ELECTRICAL PROPERTIES				
Dielectric Constant				
60 Cps	5.2	5.2	6.3	5.4
1 Mc	4.0	4.4	4.3	4.3
Dielectric Strength, v/mil				
Short-Time	350	375	400	375
Step-by-Step	340	375	375	325
Dissipation Factor				
60 Cps	0.030	0.030	0.050	0.038
1 Mc	0.016	0.016	0.023	0.017
Arc Resistance, sec	120+	180+	180+	180+

According to the producer, the plastics compound is not necessarily designed to replace melamine or straight phenolic compounds. It is especially recommended for products where the moldability of phenolics is required and where additional light-stable colorability is beneficial and essential. Typical parts that might be made of the compound include electrical and washing machine parts, handles, and appliance trim and housings. Properties of a gray woodflour - filled melamine - modified phenolic compound are given in Table 2.

TABLE 2—PROPERTIES OF GRAY MELAMINE-PHENOLIC COMPOUND

PHYSICAL PROPERTIES	
Specific Gravity	1.48
Mold Shrinkage, in./in.	0.0075
Water Absorption, %	0.4
Heat Resistance, F[a]	300
MINIMUM MECHANICAL PROPERTIES	
Tensile Strength, psi	5500
Flexural Strength, psi	8000
Notched Izod Impact Strength, ft-lb/in.	0.26
ELECTRICAL PROPERTIES	
Dielectric Strength (short-time), v/mil	300
Power Factor (1 mc)	0.05

[a]Aged 2 hr with no appreciable change in color.

4. Nylon sheet, film

Commercial production of nylon (type 6) sheet and film was announced by two companies at the show.

The sheet is available from Chicago Molded Products Corp., 2717 N. Normandy Ave., Chicago 35. It is supplied in widths up to 60 in. and in thicknesses of 0.005 to 0.060 in. The sheet is either transparent or translucent, depending on thickness.

The film is available from Ludlow Papers, Inc., Plastics Div., Needham Heights 94, Mass. It is supplied in widths up to 60 in. and in thicknesses of 0.005 in. or more. The film is supplied either transparent or colored.

5. Plastics foam films

Polyethylene (higher and lower densities) and polystyrene foam in the form of films are now available in developmental quantities. The films are expected to find use as

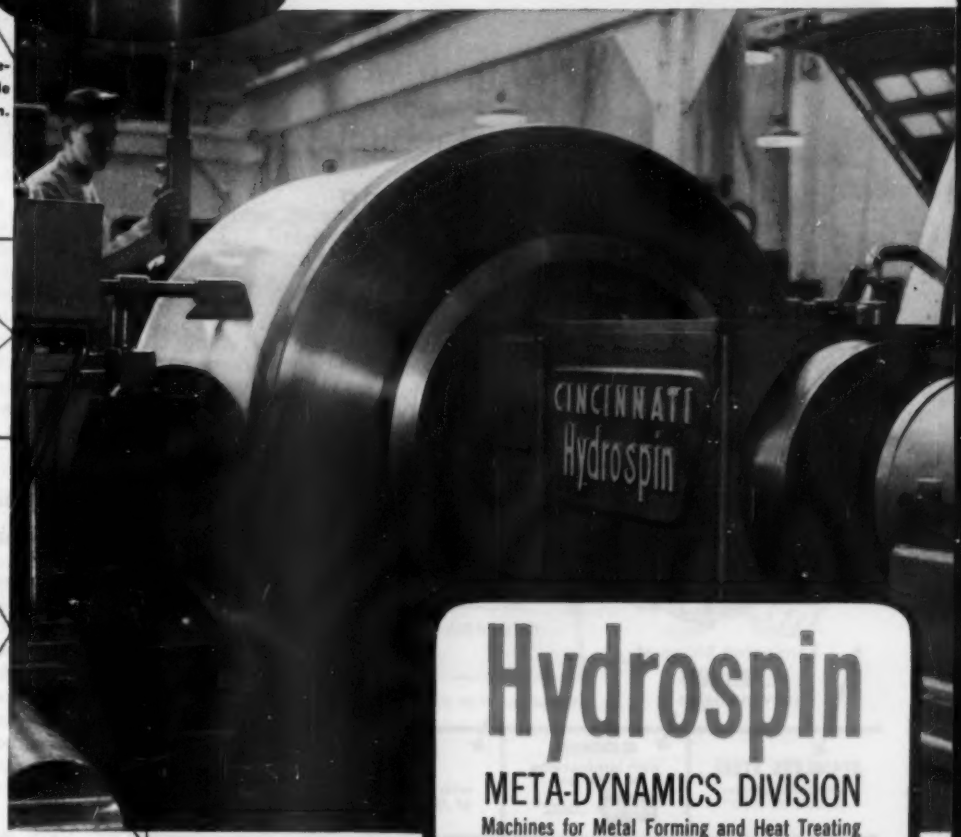
For more information, circle No. 435 ➤

Hydrospinning makes BIG NEWS *For Producing Guided Missile Hardware*

Part (A) is spun from preform (B)—using this double roller Cincinnati Hydrospin.

"*Chipless Machining*" by the Cincinnati Hydrospin® offers an unsurpassed method for producing lighter, stronger, guided missile hardware at tremendous savings in materials and production time. Many types of exotic, high tensile strength alloys—ferrous and non-ferrous—which reduce weight, can be used. With low-cost tooling, parts are quickly produced to accurate dimensions . . . have fine finish . . . with increased strength, hardness and fatigue resistance.

Development work that has been conducted indicates that parts up to 98″ diameter, and larger, can be successfully Hydrospun. For full details, call in a Meta-Dynamics Division field engineer.



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META-DYNAMICS DIVISION

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TABLE 3—PROPERTIES OF POLYETHYLENE FOAM FILMS

Type →	Orthofoam[a]	Metafoam[b]
Ten Str, psi	250-1500	6300-12,000
Elong, %	3-7	2.5-5.0
Elmendorf Tear Str, gm/mil	320–no tear	192-432
Mullen Burst Str, psi	32.5	37
Heat Sealing Temp Range, F	180-200	230-250
Max Use Temp, F	230	230
Min Use Temp, F	−60	−100
Flammability	Slow burning	Slow burning
Folding Endurance	Very high	Very high

[a] Low density material.
[b] High density material.

thermal insulations. Both the polyethylene and the polystyrene foam films are vacuum formable.

The polyethylene foam film was announced by Ludlow Papers, Inc., Plastics Div., Needham Heights 94, Mass. It is available in thicknesses of 16 to 35 mils at an average density of 0.375 gm per cu cm for low density material (Orthofoam) and 0.426 for high density material (Metafoam). The films are supplied translucent or colored. Properties of Orthofoam and Metafoam polyethylene foam films are given in Table 3.

The polystyrene foam film was announced by Koppers Co., Inc., Chemical Div., Koppers Bldg., Pittsburgh 19. It is available in thicknesses of 7 to 100 mils at two densities.

Composite Electroplate Protects Molybdenum

A composite electrodeposited coating of nickel over chromium protects molybdenum metal against oxidation for over 1000 hr at 1800 F, and over 300 hr at 2000 F.

The two-layer electroplate is considered a promising material for use on turbine blades and similar high temperature parts. It was developed by the National Bureau of Standards in research performed for the Navy Bureau of Aeronautics.

How electroplate performs

Tests show the electroplate is oxidation resistant, nonporous and ductile. Bend tests show breaks occur within the molybdenum itself

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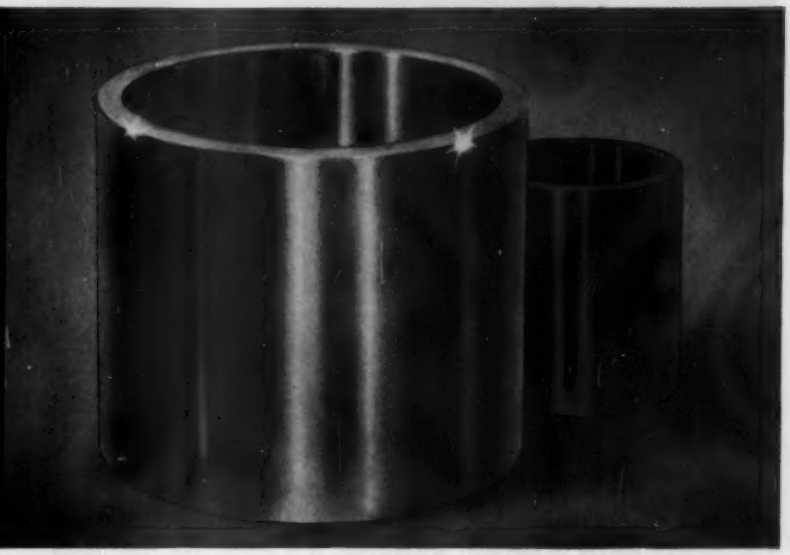

The important difference between the porous bronze bearing (right) and the all-new Iron OILITE* 212 Bearing (left) is cost. While both bearings give long, maintenance-free service, Iron Oilite 212 bearings now open the door to major savings for many equipment manufacturers.

Performance-proved in life tests and on actual products, Iron Oilite 212 bearings have a service life equal to porous bronze when used for products where corrosion is not a problem and mechanical strength requirements are within tolerable limits.

A high oil content — approximately 20% by volume — assures adequate lubrication for the lifetime of many end products. In addition, a unique built-in service factor gives Iron Oilite 212 bearings extraordinary protection against temporary overloads. They perform best when carrying medium to heavy loads at relatively low speeds and readily equal the performance of bronze at the high speeds required by home appliances, fractional horsepower motors, power tools, light machinery and other products.

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free sample

of IRON OILITE 212 Bearing 1" ID x 1¼" OD x 1" Length and full information on request. Consult the Oilite engineer in your area. Find him in the Yellow Pages under "bearings" or write direct to Amplex.

COMPARISON OF TYPICAL PHYSICAL PROPERTIES

	Iron Oilite 212	Oilite Bronze
Porosity, % oil by volume	18 - 23	18 - 23
Ultimate Tensile Strength, (psi)	10,000	18,000
Compressive Yield Point, (psi)	9,500	20,000
Rockwell Hardness	RH - 35	RE - 65
Specific Gravity	6.1 - 6.5	6.4 - 6.7

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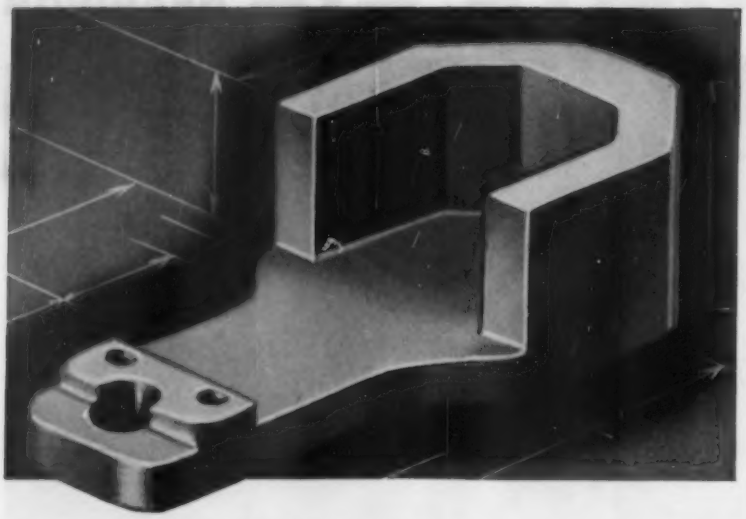

The photograph shows a bearing support plate for a new line of power tools manufactured and marketed by a large and very capable organization.

The complex nature of the part is apparent at a glance and the cost of machining such a part is evident to the eye of engineer and designer.

It is on parts of this nature that powder metallurgy offers its greatest advantages and its greatest opportunities for the future.

Such parts require most careful designing of the tooling from which they are produced, plus painstaking and tedious effort until the part can finally be produced in volume.

A manufacturer with such requirements naturally turns to Bunting where the necessary persistence until success is achieved is one of the Company's recognized characteristics.

For the unusual, as well as the usual, in bearings, bushings, bars and special parts of cast bronze or sintered metals, see Bunting first.

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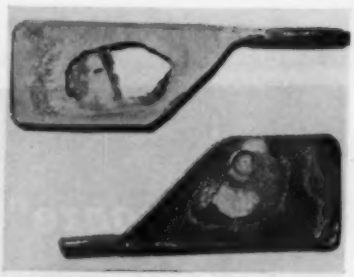
What's new IN MATERIALS



***Oxidation** at high temperatures causes severe damage to molybdenum metal. Test panels shown above were aged 300 hr at 2000 F.*

and not between the electrodeposited layers, indicating excellent adhesion of the electroplate to the basis metal.

Other tests show that small amounts of molydenum which diffuse into the surface of the electroplate do not appreciably affect the grain structure of the chromium-nickel electroplate. Results of these and other tests may be found in *NBS Technical Report 2291.*

How electroplate is applied

In plating molybdenum metal with the composite electroplate the metal is first etched with acid, then electroplated with chromium. The chromium-plated surface is etched with acid, given a nickel strike, and plated with nickel.

Five-Ply Strip for Vacuum Tube Anodes

A five-ply strip material consisting of a copper core clad with a layer of iron and a layer of aluminum on both sides has been developed by General Plate Div., Metals & Controls Corp., Attleboro, Mass., in cooperation with General Electric Co. The copper core is said to account for up to 40% of the total strip thickness.

Called Aliron, the material is designed especially for radio tube anode plates. The producer says the aluminum and iron layers become dark gray and highly emissive through the formation of an aluminum-iron compound when heated or fired during final tube assembly. This feature, combined with high

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thermal conductivity of copper, is said to offer a material with good anode heat-dissipating characteristics.

According to the producer, all the components of the aluminum and iron clad copper strip are inseparably bonded together without the use of intermediate brazing materials.

Aliron is now being produced in continuous strip in thicknesses down to 0.007 in.

TFE, Polyurethane and Silicone Rubber Tapes

Recent developments in tapes include three supported and unsupported silicone rubber tapes, a polyurethane foam tape and two TFE tapes.

1. Silicone rubber tapes

Two companies, Raybestos-Manhattan, Inc., Asbestos Textile Div., Manheim, Pa., and Permacel-Lepage's Inc., New Brunswick, N.J., have recently introduced supported and unsupported silicone rubber tapes.

Supported tapes: Raybestos-Manhattan's tapes, designated Novabestos 7526 and 7527, are supported asbestos fiber-reinforced silicone rubber tapes for use as primary and secondary insulations for power cables.

Novabestos 7526 is supported with parallel strands of glass yarn and has a unidirectional tensile strength of 75 psi. The tape is applied by overlapping.

Novabestos 7527 is supported with a glass scrim and has a tensile strength of 75 psi (lengthwise) and 50 psi (crosswise). The tape is applied by butt wrapping.

Both tapes are said to have good resistance to heat, oil and moisture. A seven-day heat aging test, conducted by daily heat cycling the tapes 7 hr at 400 F, 5 hr at 450 F and 6 hr at 550 F, indicates the tapes have a weight loss of about 11% and a reduction in dielectric strength from 450 to 375 v per mil; after 14 days the weight loss was 12.6% and the dielectric strength 340 v per mil.

Unsupported tape: Permacel-Lepage's tape, designated Type 2650,

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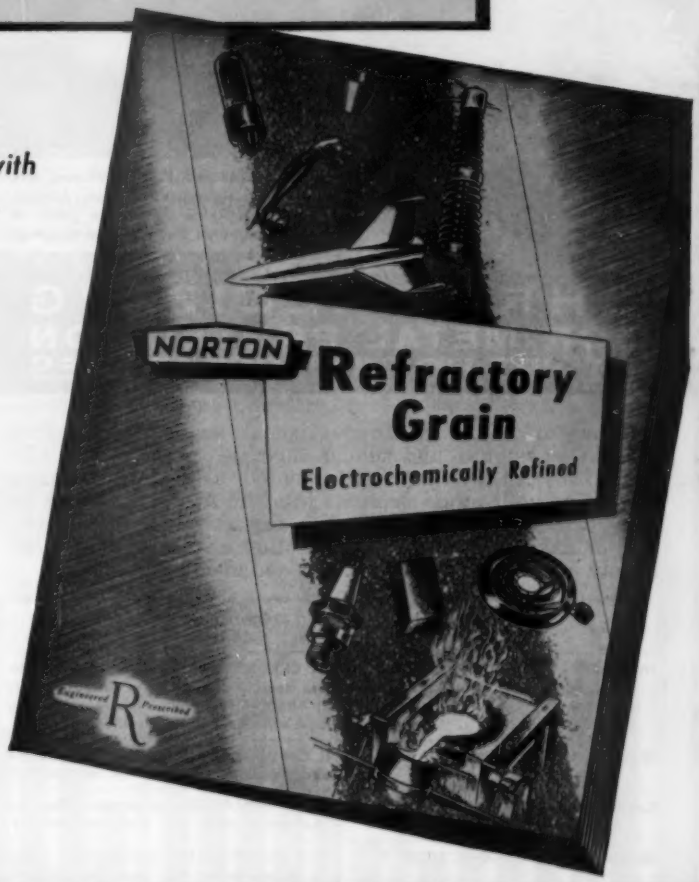
✓ *if you are concerned with processing that involves temperatures ranging upwards to 4000°*

✓ *if your progress in processing depends upon materials of high purity.*

✓ *if it would help you to obtain a modern material with unusual electrical characteristics.*



Here is a valuable reference book that tells you all about the chemical and physical characteristics of such materials as CRYSTOLON* Silicon Carbide, ALUNDUM* Aluminum Oxide, MAGNORITE* Magnesium Oxide, Fused Zirconia and Boron Carbide.

Describing how these electrochemically refined materials react under varying conditions, this book gives you plenty of facts on materials that are helping to solve processing problems.

Get this useful help towards solving your own processing problems. Write today for your free copy of "Norton Refractory Grain." NORTON COMPANY, Refractories Division, 341 New Bond Street, Worcester 6, Mass.

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Torch test of molybdenum at 2600° F.

W-2 CHROMALLIZED specimen, left, completely resists oxidation. At right, volatile oxide vapors are given off by untreated piece as it burns away.

CHROMALLIZING FOR METAL PROTECTION AT JET-HOT TEMPERATURES

Improve oxidation and thermal shock resistance of metals used in jet engines and similar superheat applications with CHROMALLIZING. This patented method of diffusing chromium with other elements into the surface provides an alloy case which is integral with the base metal. It can't peel or flake; the chromium and other elements diffuse uniformly into recesses, pores, cracks and even blind holes.

Alloy	Usual Operating Temperature	Operating Temperature of CHROMALLIZED Alloy
Iron Base (including stainless steels)	1500° F	SA CHROMALLIZED 310 and 321 stainless steels show no failure after 18 hours at 1950° F in an atmosphere containing lead bromide and lead sulfide.
Nickel Base	1800° F	U CHROMALLIZED nickel base alloys are unattacked after 200 hours at 2000° F.
Cobalt Base	1800° F	SAC CHROMALLIZED cobalt base alloys are unattacked after 150 hours at 2200° F.
Molybdenum	Over 2000° F	W-2 CHROMALLIZED molybdenum shows no failure after 400 hours at 2350° F, after 48 minutes at 2800° F, and after one minute at 3400° F.

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What's new IN MATERIALS

is an unsupported, self-bonding silicone rubber tape. The producer says the tape is potentially useful for insulating formed coils, cable splices, bus bars and transformers. The tape can be exposed to weather, ozone, and constant moisture without harm. Because the tape is unsupported and has a high degree of elongation, it should be a good insulator for irregular electronic shapes. The tape cures to a homogeneous mass after aging two or three days at room temperature.

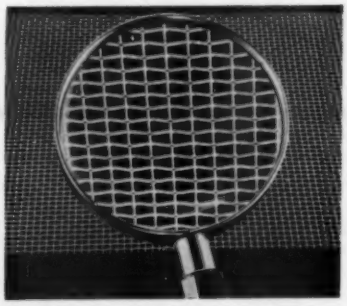
2. Polyurethane foam tape

United Mineral & Chemical Corp., 16 Hudson St., New York City has introduced a polyurethane foam tape called Tesamoll for use as a lining, mounting, sealing and vibration absorbing material for radio, TV, switchgear, and other electrical and electronic equipment; furniture; automobiles; and aircraft.

The tape is backed by a pressure sensitive adhesive that is said to adhere to any dry, clean metallic or nonmetallic surface. The tape, because it is electrostatically negative, is said to repel dust and other airborne particles. The tape is supplied in ¼ and ⅝ in. widths.

3. TFE tapes

Two companies, Connecticut Hard Rubber Co., 407 East St., New Haven 9, Conn., and Dilectrix Corp.,



Brazed wire cloth—The stainless steel wire cloth shown here is copper brazed at each intersection after weaving to provide a structure that blocks shifting of wire in any direction during service. The cloth is woven from 0.020-in. dia T-304 stainless steel wire. The cloth is available from Cambridge Wire Cloth Co., Cambridge, Md.

NEW

a super-hard cemented carbide for high speed, high precision machining of steel

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now added to Carmet's crater-resistant 600 series

Here's a new product of Allegheny Ludlum research to help you meet today's demand for high speed machining of steel. It's an ultra hard tungsten carbide with unusually high crater resistance, wear life and high strength at high cutting temperatures. CA604 operates in the fast cutting ceramic areas, combines high velocity finishing with light to medium feeds. Field tested for more than a year, CA604 is offered in Indexable Inserts and blanks for mechanical holders.

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Extra hard for high speed, high precision machining.

CA 605
For fine finishing and high velocity cuts of steel.

CA 606
For lighter cuts on all steels and magnetic alloys

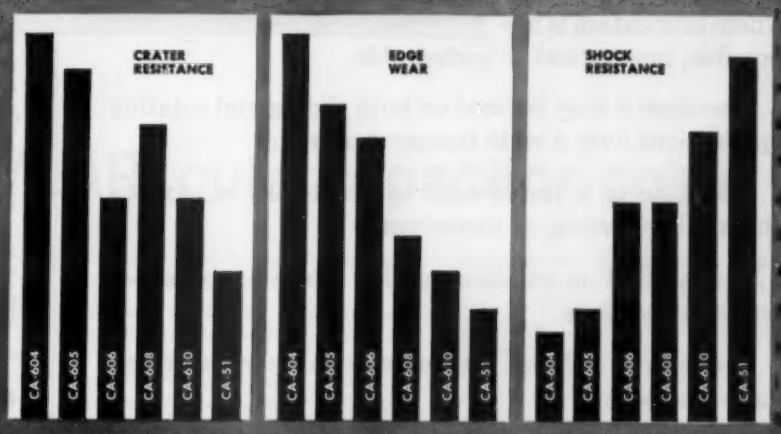
CA 608
For light cuts on all steels; crater resistance.

CA 610
General purpose steel cutting; high shock resistance.

CA 51
For heavy, interrupted cuts; high shock resistance.

Relative Characteristics of Carmet Metal Cutting Grades

This chart shows how grades in the CA-600 Series compare in crater resistance, edge wear resistance and shock resistance. The units of measurement indicate only relationship between grades, not efficiency.



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What's new IN MATERIALS

Allen Blvd. & Grand Ave., Farmingdale, N. Y., have introduced cast TFE tapes for electrical applications.

Connecticut Hard Rubber Co's tape, called Temp-R-Tape C, has a dielectric strength of 2750 v per mil and an operating temperature range of −100 to 500 F. The tape is made of specially produced 0.0015-in. cast TFE film backed with a heat curing pressure sensitive silicone rubber adhesive. It has good moisture resistance, high elongation (475%) and high bond strength. Anticipated applications include slot lining, interlayer and interphase insulation, coil wrapping, wire splicing and harness bundling for Class 180 C (360 F) (Class H) and higher temperature requirements. The tape can also be used in mechanical applications.

Temp-R-Tape is supplied in 18-yd rolls in widths of ¼, ½, ¾ and 1 in.

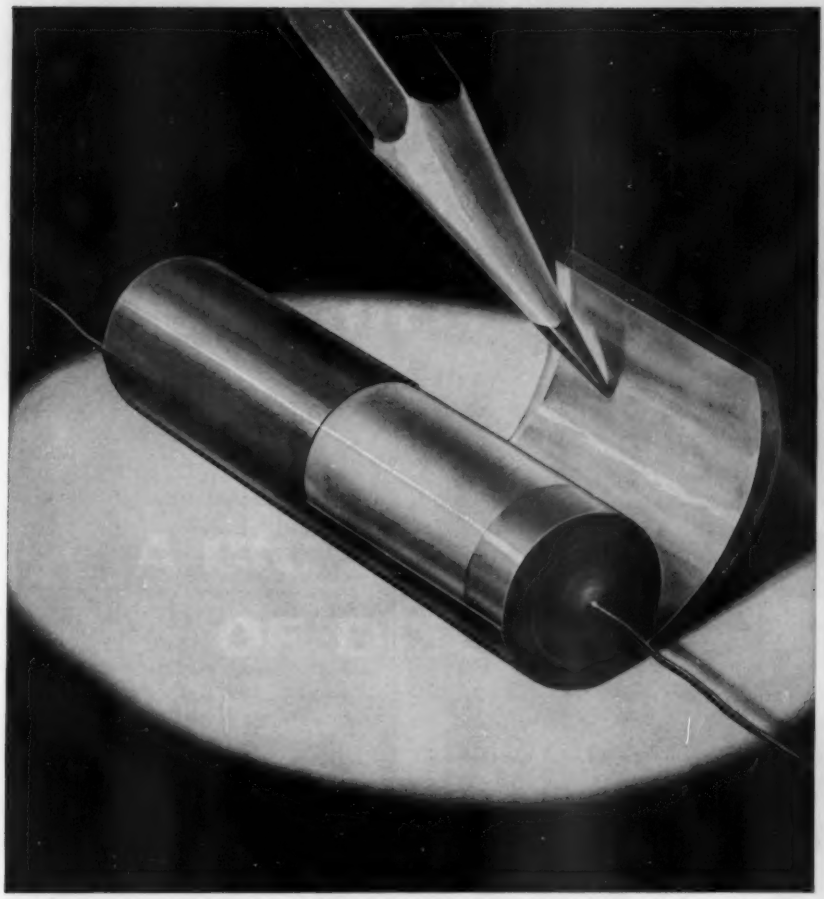
Dilectrix Corp.'s tape, called Type LT, has a pressure sensitive backing which adheres to wood, metal, glass and ceramics. The cast tape has potential use as: 1) a dielectric in capacitors, 2) a shield for wires and cables, 3) a thin interlay for transformers and coils, 4) a slot liner and interphase insulation, 5) general insulating at electrical junctions, and 6) color coding.

Type LT is supplied in continuous roll lengths of 100 and 500 ft and in widths from ¼ to 12 in. It is available in thicknesses from 0.25 to 4.0 mils.

Copper Alloy Rod Is Easy to Fabricate

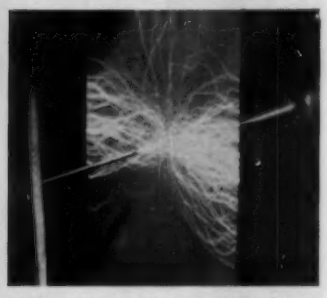
A copper alloy rod recently developed has a machinability rating of 90 (free-cutting brass = 100) and cold working characteristics comparable to pure copper. The rod also has excellent hot working characteristics for forging and pressing.

Developed by Scovill Mfg. Co., Mill Products Div., Waterbury 20, Conn., the alloy is designated OFHC + Sulfur Copper (Alloy No. 1082). The company says the rod should find use in such electrical, electronic and aircraft parts as cable clamps, pins,



PROPERTIES OF "MYLAR"

"Mylar" offers a unique combination of properties that may help you improve performance and lower costs of your product. Here are two of the many important properties for evaluation.



HIGH DIELECTRIC STRENGTH: Average of 4,000 volts per mil . . . average power factor of 0.003 at 60 cycles.

SUPERIOR CHEMICAL RESISTANCE: Unaffected by oils, grease, most acids and alkalis, moisture and solvents.

Western Electric reports . . .

Du Pont MYLAR® cuts capacitor costs

PROBLEM: Western Electric was searching for a dielectric material which, when used in film-foil construction, would lower manufacturing costs.

SOLUTION: Du Pont "Mylar"* polyester film. According to Western Electric, the moisture resistance of "Mylar" minimized the need for costly encapsulation; high dielectric and physical strength in thin gauges helped reduce over-all size; capacitance stability under normal voltage stress maintains long life.

RESULTS: Capacitors insulated with "Mylar" provide excellent performance for selected types of equipment produced by Western Electric. These new capacitors achieve high reliability and long life. Materials savings have been realized through reductions in size and use of less costly encapsulation.

HOW CAN "MYLAR" HELP YOU? Whether your product uses miniaturized capacitors or heavy-duty cables, it will pay you to investigate the performance benefits of "Mylar". . . and products made with "Mylar". Component makers find this tough, thin polyester film will often cost less on an area basis than present insulating materials. For more detailed information, send in the coupon.

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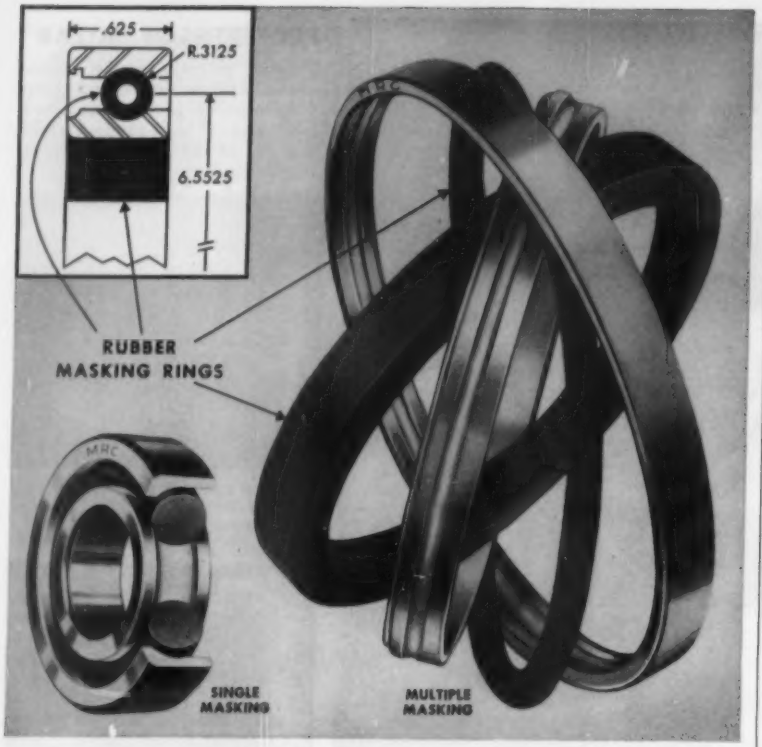

Photos courtesy Marlin-Rockwell Corp., Jamestown, N. Y.

Rubber Rings Mask Bearings during Plating Process

Here's a new way to mask out plating on bearing race grooves without tedious hand-labor. Regardless of bearing size, rubber rings are fitted precisely into ball grooves and inner ring bore so that plating can't sneak under the rubber even in torturous electroplating baths. Clean division lines always result. Inner ring and outer ring are held together so both can be plated simultaneously. This saves one complete plating cycle. And, this fast assembly prepares bearings for plating in seconds—eliminates costly hand-painting with unreliable stop-off lacquer.

These rubber rings are the result of Marlin-Rockwell Corporation (Jamestown, New York) consulting Continental to solve an important masking problem. Creative engineering successfully developed these extruded and spliced, or molded rubber rings which increased production 2000%—20 times faster than hand-painting. What's more, the special rubber compound withstands repeated baths in blistering acids and caustics without affecting precise dimensions, elasticity or resilience.

This rubber ring technique is typical of the thinking and ingenuity behind rubber parts by Continental. It also represents the economy and better end results accomplished by consulting a rubber specialist *during the planning stage* of a product. If you need help like this, call or write Continental—rubber specialists since 1903.

Engineering catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

Another achievement in **RUBBER**
engineered by **CONTINENTAL**

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For more information, turn to Reader Service card, circle No. 520

What's new IN MATERIALS

PROPERTIES OF ALLOY 1032

PHYSICAL PROPERTIES	
Density, lb/cu in.	0.023
Specific Gravity	8.94
Coef of Ther Exp, 10^{-6} per °F	9.8
Ther Cond, Btu/hr/sq ft/°F/in.	216
Melting Point, F	1980
MECHANICAL PROPERTIES[a]	
Tensile Strength, psi	53,000
Yield Strength (0.5% ext under load), psi	50,000
Elongation, %	10
Rockwell Hardness	B60
ELECTRICAL PROPERTIES	
Volume Resistivity, ohm-cm	10.8
Electrical Conductivity (IACS at 68 F), %	96

[a]Of a specimen drawn 40%.

radio parts, prongs, welding and soldering iron tips, contact pins and screw machine parts.

Electrical conductivity of the copper alloy rod is approximately 96% IACS (68 F), compared to 90% for tellurium copper. The material is more ductile than tellurium copper and its general corrosion resistance is comparable to that of pure copper. The new alloy has good resistance to stress corrosion cracking.

The sulfur copper rod finishes readily in its own copper color and can be electroplated. According to Scovill, the main advantage of sulfur copper over tellurium copper is better electrical and thermal properties, as well as superior ductility. The main advantage of sulfur copper over leaded copper is much better ductility.

Rubber-Like Adhesive Bonds to Any Surface

A new family of rubber-like adhesives is described as materials that can't resist a strange molecular impulse to bond to nearly any surface. Chemical "hooks" attached to each molecule of the material compel the adhesive to cling to and join surfaces which, in many cases, have defied adhesion until now. When this happens, the adhesive forms a lasting bond between similar and dissimilar materials. Developed by B. F. Goodrich Industrial Products Co., Akron, Ohio, the adhesives bond ma-

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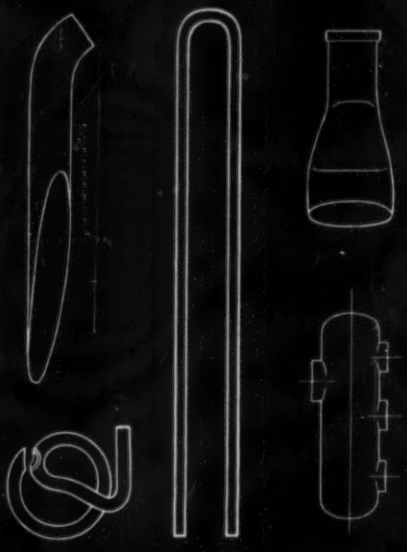
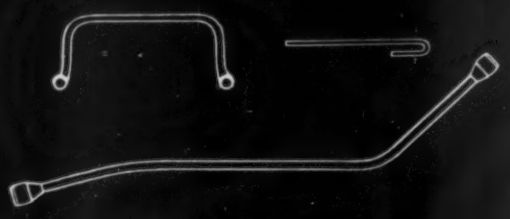


A BIG STOCK OF DIES



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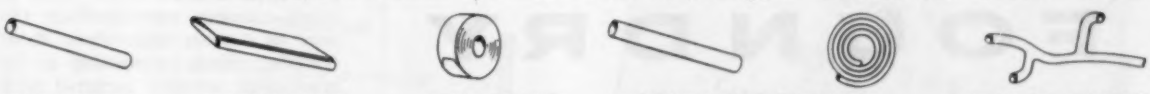
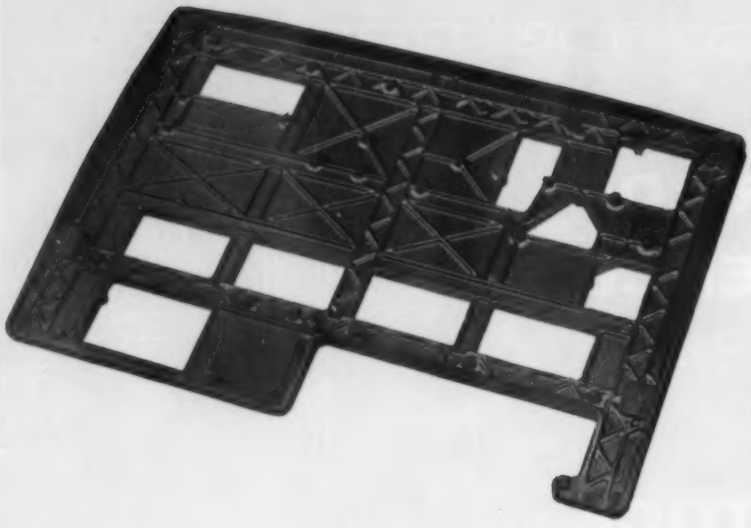


METALFLO LOCKSEAM COIL STRIP SEAMLESS TUBING TUBULAR PARTS

For more information, turn to Reader Service card, circle No. 490



DUCTILITY

A CASE IN POINT—This ninety-six pound casting was made for the National Cash Register Co. of Nodulite®, Hamilton Foundry's ductile iron. The casting forms the base for the new Post-Tronic Accounting Machine. It measures 37½" by 23½" with sections varying from ¼" to 1½". Ductile iron was chosen for this part because of its ductility, dimensional stability, rigidity, and machinability.

Ductile iron has most of the engineering advantages of steel yet it can be designed with the same flexibility and cast with the same procedures used for gray iron. It has high strength: up to 120,000 psi minimum tensile strength in standard grades. It is tough: Charpy impact strengths up to 115 ft.-lbs. in standard grades. It is ductile: elongation is possible up to 25% after short time annealing. And it is wear resistant: spheroidal graphite particles provide for self-lubrication. Hamilton Foundry regularly casts 60-45-10, 80-60-03, 100-70-03, and 120-90-02 grades of ductile iron as well as high alloy Ductile Ni-Resist.

When new and unusual design problems arise in the selection of metal and the casting of parts, you will find that the skill and integrity of your foundry is your best insurance that specifications—and delivery schedules—will be met.

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HAMILTON FOUNDRY

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For more information, turn to Reader Service Card, circle No. 446

terials together without heat or special surface treatments.

One member of the family is now available as a laminating adhesive. It is known as A-916-B and is potentially useful for joining together films of Mylar, cellophane, cellulose acetate, polyethylene, polyvinyl chloride, Saran and nylon. Adhesive A-916-B also has potential use for bonding polystyrene foam.

Filled TFE Performs Well in Liquid Nitrogen

A filled TFE composition had the lowest coefficient of friction and the best wear properties of any material tested in a friction study of various materials in liquid nitrogen.

Tests on TFE and other materials were conducted by D. W. Wisander, W. F. Hady and R. L. Johnson, of Lewis Flight Propulsion Laboratory. Data were obtained with a sliding-friction apparatus consisting of a hemisphere-tipped rider specimen sliding in a circumferential path on the flat surface of a rotating disk submerged in liquid nitrogen. A surface speed of 2300 fpm was chosen as representative of conditions in some positive displacement pumps for cryogenic liquids. The test load of 1000 gm gave an initial Hertz surface stress of approximately 150,000 psi with steel specimens.

Test results

Details of this study may be found in Technical Report No. 4211 issued by the National Advisory Committee for Aeronautics.

Other conclusions reached by the investigators:

1. Cooling by the liquid nitrogen probably played a vital role in the good results obtained with TFE compositions. Failure of Teflon in slider applications at room temperature has previously been associated with thermal degradation accentuated by poor thermal conductivity.

2. Friction and surface failure properties of metal combinations in liquid nitrogen were basically the same as at room temperature. Metal transfer either by welding or by mechanical adhesion occurred with both soluble (type 304 stainless steel

For more information, circle No. 506 ➤

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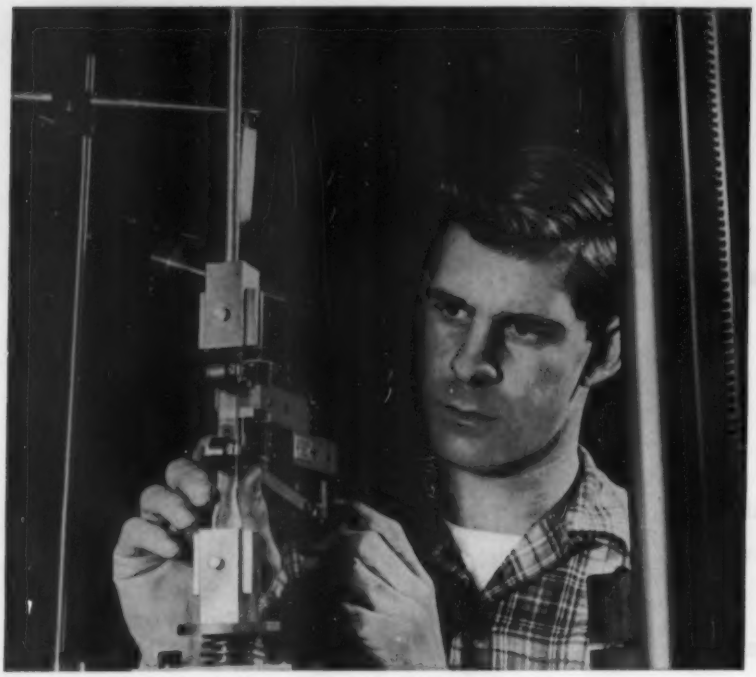

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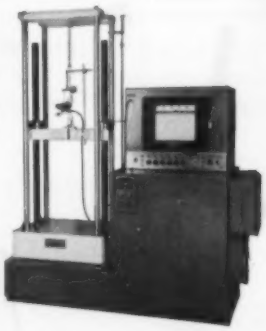

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What's new IN MATERIALS

on type 304 stainless steel) and nonsoluble (silver on type 304 stainless steel) metal combinations. Considerable plastic deformation was observed, and interface ductility was greater than at room temperature. Except for a silver composition containing molybdenum disulfide, all metal combinations that included SAE 1020 had a coefficient of friction greater than 0.52.

3. Molded carbon materials that are commonly used in sliding seals wore very rapidly in liquid nitrogen. Wear of the carbons was decreased significantly by a metal-haloid impregnant of the type used to inhibit "dusting" of aircraft generator brushes at high altitude.

4. Laminated phenolic compositions had high friction, developed a burnished transfer film on the mating surface, and wore considerably more than TFE compositions. Additives such as graphite and molybde-

Epoxy electrical parts — Anhydride-cured epoxy electrical and electronic parts similar to the ones shown above are said to have better physical and electrical properties at high temperatures than parts cured with conventional amine curing agents. The parts are made of epoxy potting compounds available from Mitchell-Rand Mfg. Corp., 51 Murray St., New York City. The anhydride curing agents used in the formulations are marketed by Allied Chemical Corp., National Aniline Div.

According to Allied Chemical, weight loss of the anhydride-cured formulations at high temperatures is frequently less than for amine-cured formulations, indicating a thermally stable material. Because of this thermal stability, anhydride-cured epoxy parts are less likely to crack during thermal cycling than amine-cured parts.

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Alkalume LC-1 is a specially developed immersion-type cleaner for removal of buffing compounds and soil from all metals, prior to plating or anodizing.

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What's new IN MATERIALS

num disulfide did not improve the performance of the laminated phenolic compositions.

Finish for Aluminum Is Corrosion Resistant

A new chemical process for finishing aluminum produces a grainy-structured satin finish on aluminum alloys. The finish is unaffected by all solvents, mild alkalis and acids. It is said to be low in cost.

The non-electric process for finishing aluminum was developed recently by Republic Chemical Co., 13068 Saticoy St., North Hollywood, Calif. The process is called Recodizing.

The firm reports that finished surfaces have excellent paint bond ability without priming, and high impact and abrasion resistance. The surfaces are electrically conductive. Also, treated aluminum surfaces can be refinished after years of outside exposure without removal from the installation. The finish is unaffected by rapid or slow temperature changes.

TFE O-Rings

Mirror-Finish is the name given to a line of TFE o-rings introduced recently by Chicago Gasket Co., 1271 W. North Ave., Chicago. The rings are made by a new process which is said to turn out parts having an exceptionally smooth surface and free

***Flexible TFE rings** are available in over 140 sizes from Chicago Gasket Co.*

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Coating thicknesses are precise, range from 10 to 150 mils.

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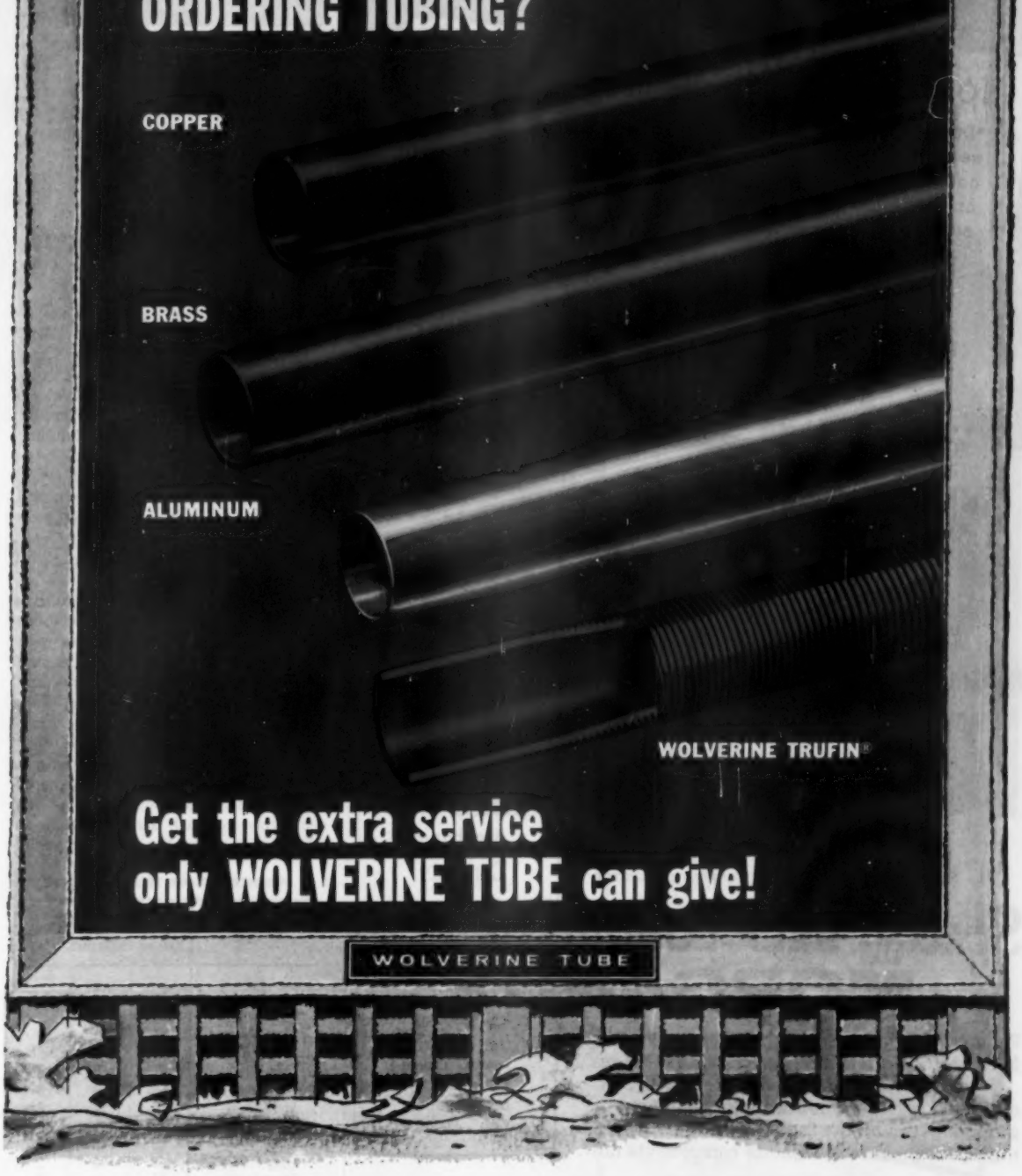

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Morganite ordered for use on all future runs."

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Chief Test Engineer

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What's new IN MATERIALS

of raised flash that exists on conventional TFE rings. The rings are stable up to 500 F and are impervious to oils, solvents, hydraulic fluids, acids and other corrosive chemicals.

Aluminum Alloy 7079 Available as Plate

A new fabricating technique is now turning out aluminum alloy 7079-T651 as thick plate. Chief advantage of the plate is its ability to be machined into longer and wider aircraft parts than parts formed from large hand forgings. Ranging in thickness from 3 to 6 in., the new plate is guaranteed to be within the ultrasonic testing acceptance limits for class A areas as determined by the Society for Nondestructive Testing.

The producer, Aluminum Co. of America, 1501 Alcoa Bldg., Pittsburgh 19, says the plate combines excellent mechanical properties with freedom from distortion. Also, the plate is said to maintain good ductility in both the short and long transverse directions. Minimum mechanical properties are guaranteed in three directions: 1) longitudinal, 2) long transverse, and 3) short transverse. The product has potential use for such aircraft parts as bulkhead assemblies and integrally

PROPERTIES OF 7079-T651 PLATE

Thickness, in. ↓	Ten Str, 1000 psi	Yld Str, 1000 psi	Elong, %
3.001–4.000			
Long.	70	60	6
Long Trans.	70	60	5
Short Trans.	64	55	2
4.001–4.500			
Long.	68	58	6
Long Trans.	68	58	5
Short Trans.	62	54	2
4.501–5.000			
Long.	68	58	5
Long Trans.	68	58	5
Short Trans.	61	53	2
5.001–5.500			
Long.	67	58	4
Long Trans.	67	58	4
Short Trans.	60	53	2
5.501–6.000			
Long.	67	58	4
Long Trans.	67	58	4
Short Trans.	59	52	2

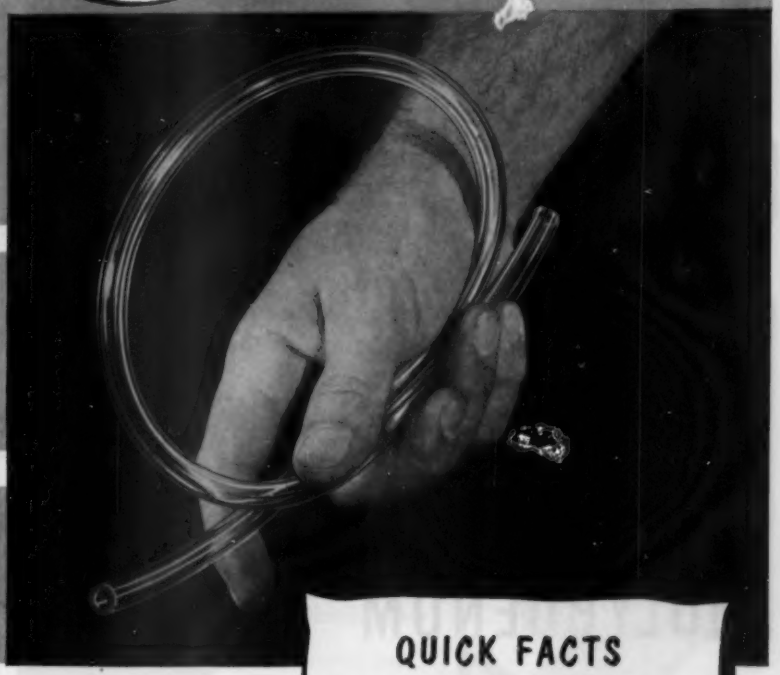
Where can this FLEXIBLE, clear, plastic tubing fit into your plans?

TYGON

✔ If you convey corrosive gases and liquids.

✔ If you convey liquid food products.

✔ If you require flexible lines with solution visibility.



Chemically-resistant, non-toxic, supple as a fly line, Tygon clear flexible plastic tubing is the ideal medium for those tough-to-solve piping problems.

Possessing a flex life ten to twelve times that of rubber, free of aging characteristics, Tygon serves equally well as a permanent component in machines or as quickly assembled and disassembled, temporary or permanent plant piping.

QUICK FACTS

Six standard formulations to meet a wide range of requirements.

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stiffened wing panels.

To produce thick plate in alloy 7079, ingots are first worked on a press, then rolled, heat treated and stretched. This method is said to provide thick, homogeneous plate with a consistently sound internal structure.

Two PVC Plastics Are Fast-Extruding

Two new rigid polyvinyl chloride plastics, QGD-5020 for high impact and QGD-5010 for chemical resistance, can be extruded twice as fast as conventional rigid polyvinyl chloride compounds, according to the producer. On slightly modified commercial equipment the plastics have run as much as 100% faster than competitive rigid polyvinyl chloride compounds and have maintained better surface smoothness, it is claimed.

Both compounds are available from Union Carbide Plastics Co., Div. of Union Carbide Corp., 420 Lexington Ave., New York 17 and are priced at 42½¢ per lb in truckload lots. The company says the materials, engineered particularly for pipe and contour extrusion applications, are listed by the National Sanitation Foundation as suitable for making pipe that will carry drinking water.

QGD-5020 in extruded form has an Izod impact strength of 20 to 30 lb per in. of notch. Ratings for other commercial high impact plastics range from 0.4 to 20 lb per in. of notch, according to the producer.

Two tests were conducted to demonstrate the high impact strength of the compound. In one, 2-in. pipe of QGD-5020 withstood ten consecutive blows from a 10-lb ball dropped 10 ft. In the second, pipe samples made of the compound were filled with water and stored for 1 hr at a temperature of −109 F; the samples were then thrown onto a concrete floor. None of the new compound samples failed, whereas samples made of other rigid PVC resins shattered.

Bakelite expects QGD-5020 to be useful for automotive ducting, electrical conduits, tote boxes, cafeteria trays, barrels for fountain pens and

MAXIMUM OPERATING TEMPERATURE	SYLVANIA WIRE
( ) 1300°F	1. Silver Plated Copperweld
( ) 1100°F	2. Kulgrid® 28
( ) 1000°F	3. Nickel Plated Copper
( ) 650°F	4. Silver Plated Copper
( ) 400°F	5. Oxalloy® 28
( ) 400°F	6. Inconel Clad Copper

*Trade-mark

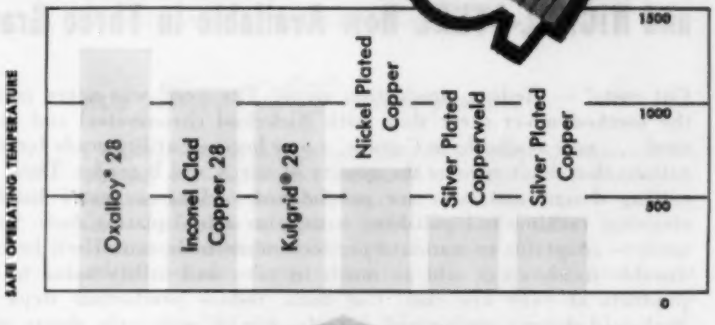
Can you match these Sylvania *High Temperature Wires* with their applications?

GET THEM ALL RIGHT? Then you're right up to date on Sylvania composite wires for high-temperature applications in corrosive and oxidizing atmospheres where good conductivity is required. (You can check your answers with the chart below.)

You may be interested in knowing, too, that new wires are under development, improving the conductivity and corrosion-resistance of plated and clad wires to operate in various ranges from 500° F to 2000° F.

A new "barrier" layer concept, improved coatings, and new composites such as aluminum-clad copper indicate the amount of effort and importance Sylvania places on its high-temperature wire development program.

If you're not yet completely familiar with Sylvania High Temperature Wires, write for your "Product Bulletin." As a major supplier of both clad and plated wires, Sylvania is in a unique position to offer objective recommendations on the best wire for your application. Address your inquiry to SYLVANIA ELECTRIC PRODUCTS INC., Parts Division, Warren, Penna.



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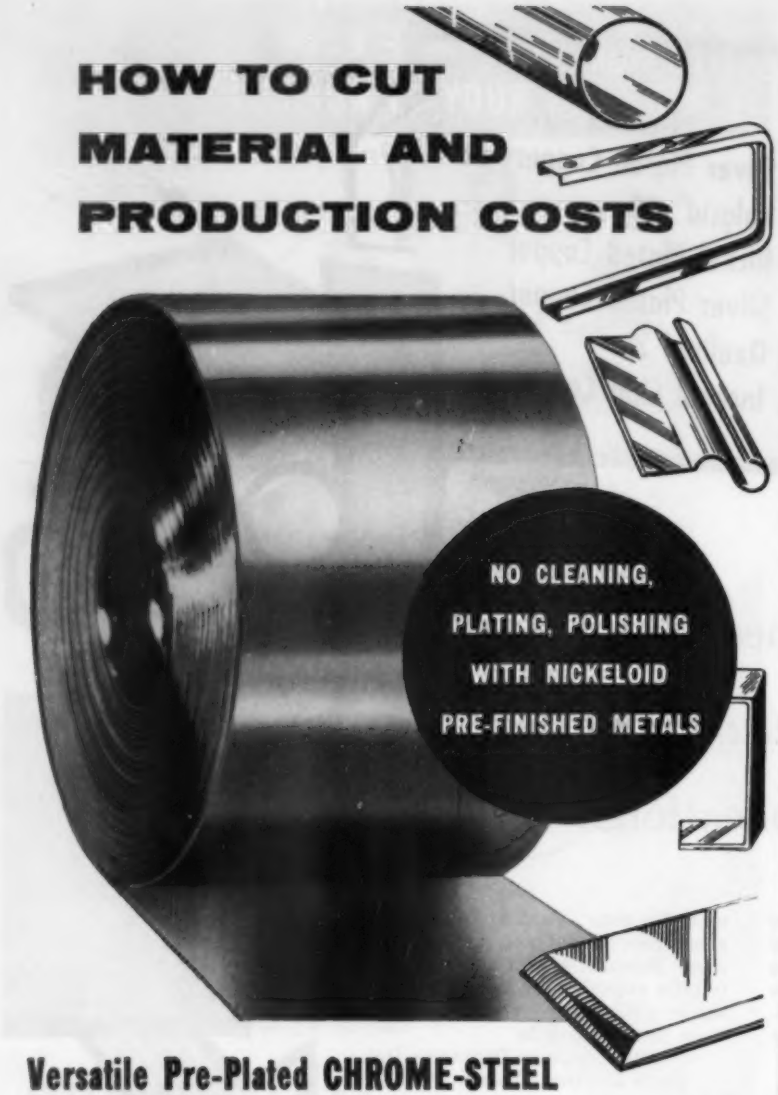
For more information, turn to Reader Service card, circle No. 368

HOW TO CUT MATERIAL AND PRODUCTION COSTS



Versatile Pre-Plated CHROME-STEEL and NICKEL-STEEL Now Available in Three Grades

Cut costs! — Reduce production steps! The *need* was never greater; the *method* never surer than with Nickeloid chrome-steel and nickel-steel . . . now available in C-grade, *a new low-cost utility grade* for applications that don't require the quality of our A and B grades. These cost-cutting design materials are *pre-finished* — eliminate extra handling, cleaning, racking and polishing costs, plus actual plating costs. So versatile — adaptable to standard production methods, too! Their beautiful durable finishes can add so much in sales and utility value to your products at very low cost. Cut costs, reduce production steps with Nickeloid chrome-steel or nickel-steel — big 24" wide coils, sheets, strips; bright and satin finishes. Now save even more with new low-cost C-grade!

NICKELOID METALS SINCE 1888 N·M

Write For More Information

AMERICAN NICKELOID COMPANY

PERU 6, ILLINOIS

MILLS — Peru, Illinois and Walnutport, Pennsylvania Sales Offices Throughout the U.S.A.

For more information, turn to Reader Service Card, circle No. 447

What's new IN MATERIALS

PROPERTIES OF PVC COMPOUNDS

Type ➡	QGD-5010	QGD-5020
PHYSICAL PROPERTIES		
Specific Gravity	1.30	1.34
Heat Distortion Temp, °F.	155	152
MECHANICAL PROPERTIES		
Izod Impac Strength, ft-lb/in.	0.6	20
Rockwell Hardness	R110	R107
Tensile Strength, psi	8500	6500
Elongation, %	50	30
Flexural Strength, psi	11,800	10,000
Flexural Modulus, psi	450,000	372,000
Pipe Burst Strength, psi		
68 F	8600	7100
105 F	7000	5500
140 F	5000	4300
175 F	1500	1200
CHEMICAL RESISTANCE[a]		
Sulfuric Acid		
Flex Str Chg, %	+9.9	+6.7
Weight Chg, %	+0.08	—0.08
Hydrochloric Acid		
Flex Str Chg, %	—42.7	—65.4
Weight Chg, %	+7.4	+23.2

[a]Aged 30 days.

automatic pencils, and window and storm sashes.

QGD-5010 is said to withstand contact with many strong acids, alkalis, metallic and ammonium salts, alcohols and aliphatic hydrocarbons. Designed for pipe requiring high chemical resistance, it is also expected to be useful for oil field and slurry lines.

Clear Anodize Applied Quickly to Magnesium

A clear anodic coating for magnesium alloys has been developed that can be applied in less than a minute. The anodize is used under lacquer or varnish for maximum corrosion protection. In 20% salt spray tests, magnesium finished with the anodize plus varnish has passed 500 hr with virtually no change in appearance.

A product of Dow Chemical Co., Midland, Mich., the anodic treatment can be applied to all forms of magnesium, including sheet, extrusions, die castings, sand castings and forgings. According to Dow, lacquer or varnish tinted with commercial dye-

For more information, circle No. 509 ➤

flowability

IS THE SECRET...

of INDIANA METAL PRODUCTS CO.'S continued success in cold heading quality fasteners

"Our objective is to give our customers a superior product at a competitive price," says Norbert Schroeder, General Manager of Indiana Metal Products Co., Division of Textron Inc., Rochester, Indiana.

To achieve this goal, Indiana specifies Keystone "XL" Wire for the manufacture of cold headed fasteners. "XL" *flowability* keeps costs competitive by eliminating downtime and secondary operations as well as increasing tool life. *Flowability* makes a superior product free from fractures, with perfectly filled corners, collars and excellent surface characteristics. This results in superior products at lowest cost.

Keystone "XL" Wire can help you, too, produce a better quality product at a competitive price. Talk it over with your Keystone representative—or call us—today!

XL's *flowability* makes possible . . .

1. Bleacher bolt—extra large head, deep Phillips recess—2 blows **2.** Brake assembly stud—round collar and square head formed simultaneously **3.** Plastic-to-metal fastener—2 blows—2 diameters plus collar **4.** Adjusting screw—5 diameters **5.** Flat pan head—must be perfectly flat **6.** Twin-fast wood screw—headed and slotted in a single blow. XL quality makes possible roll threading of this twin-fast screw with sharp *double lead* threads

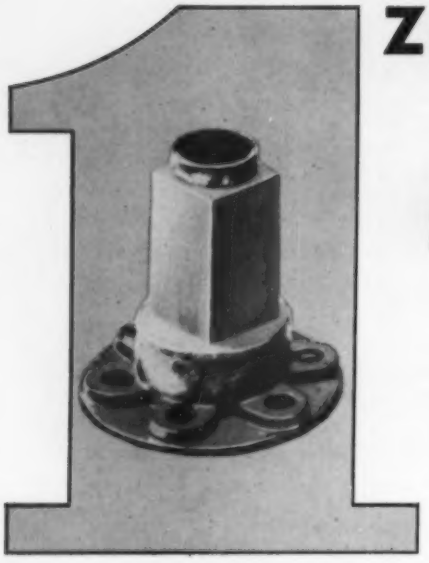
Keystone Steel & Wire Company, Peoria 7, Illinois

KEYSTONE XL WIRE STUDY

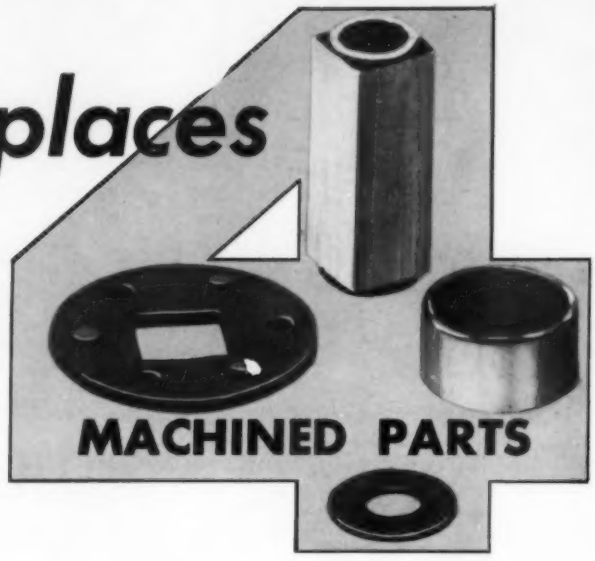
KEYSTONE

WIRE FOR INDUSTRY

ZINC DIE CASTING



Replaces



4 MACHINED PARTS

- *Eliminates Assembly*
- *Reduces Labor And Material Costs 50%*

This hub is part of the mechanism of coin-operated machines. Switching from brass and steel to a zinc die casting *slashed material and labor costs over 50%* for Chicago Coin Machine Division of Chicago Dynamic Industries.

Prior to the change, the 4-piece hub required 8 separate machining and assembly steps. The die casting however requires only 2; the casting is trimmed and the three assembly holes tapped. Scrap loss has been virtually eliminated, internal structural strength is fully retained.

The part is cast at a rate of 200 per hour in a 4-cavity mold and critical dimensions are held *as cast* to .005" overall, .003" concentricity. With annual hub requirements at 200,000, Chicago Coin Machine Division has found zinc die castings the way to meet today's rising production costs.

DIE CASTING is the Process

ZINC, the metal

BUNKER HILL

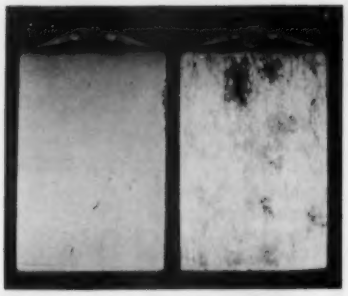
EASTERN SALES AGENTS
ST. JOSEPH LEAD COMPANY, 250 PARK AVENUE, NEW YORK 17

BUNKER HILL 99.99+% ZINC

SALES OFFICE FOR PACIFIC COAST
THE BUNKER HILL CO., 660 MARKET ST., SAN FRANCISCO, CALIF.

For more information, turn to Reader Service card, circle No. 491

What's new IN MATERIALS



***Magnesium panel** finished with clear anodize plus varnish (left) has no change in appearance after salt spray test compared to panel finished with varnish alone (right).*

stuffs can be applied over the clear anodize to obtain a transparent effect in a wide variety of colors. The colors have good permanence and are not washed out by detergents.

Phenolic Laminates for Electrical Parts

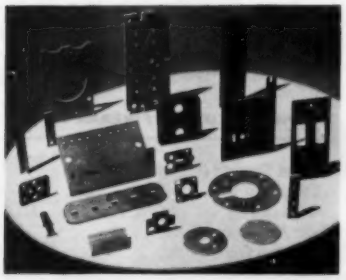
Two paper-phenolic laminates—a punching grade and a self-extinguishing grade—have been developed for electrical parts.

1. Punching grade

The punching-grade laminate is said to combine good electrical properties with good impact and flexural strengths—more than 50% greater than those of regular NEMA XXXP laminates, according to the producer.

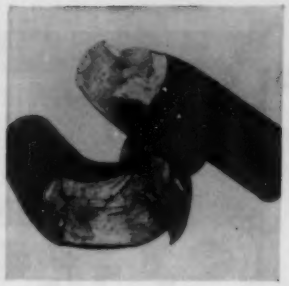
Announced by Mica Insulator Div., Minnesota Mining & Mfg. Co., Schenectady 1, N. Y., the material is designated Lamicoid 4012-42.

The material is readily machined



***Electrical parts** punched from a new paper-phenolic laminate.*

Where can you use this tough, corrosion-resistant, easy-to-work metal?



New 4-D Wrought Iron

Below are some of the many applications in which 4-D Wrought Iron tubular and flat rolled products save money.

How? By lasting longer at *lowest cost per year.* 4-D wrought iron's unique combination of corrosion-resistance, strength, weldability, machinability and heat-resistance is duplicated in no other metal.

Check or add applications in which you are interested, tear out this check list, and mail it to our Product Development Department. We will be most happy to relate 4-D's capabilities to your particular application or problem.

TUBULAR	FLAT ROLLED
☐ Heat Exchanger	☐ Nuclear Process Equipment
☐ Condensers	☐ Tanks
☐ Crystallizers	☐ Ducts and Breechings
☐ Sand Drying Equipment	☐ Protection Plates
☐ Hot Water Heaters	☐ Saggers
☐ Industrial Heaters	☐ Curing and Drying Racks
☐ Dehumidifiers	☐ Gratings
☐ Air-Conditioning Units	☐ Railings
☐ Air Preheaters	☐ Casings
☐ Degreasing and Machine Cleaning Units	☐ Containers
	☐ Washers
☐ Radiator Push Nipples	☐ Ball Pins
☐ Thermocouples	☐ Fasteners
☐ Swimming Pool Filters	☐ Brackets
☐ Diesel Exhausts	☐ Pallets
☐ Sludge Digestor Coils	☐ Pole Line Hardware

Fill in other applications on which you would like information

_____

_____

_____

A. M. Byers Company, Product Development Department
Clark Building, Pittsburgh 22, Pennsylvania

☐ Send literature ☐ Have representative call

NAME _____

FIRM _____

ADDRESS _____

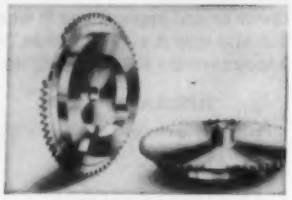
CITY _____ ZONE ____ STATE _____

BYERS 4-D WROUGHT IRON
A New Dimension in Product Design and Construction

For more information, turn to Reader Service card, circle No. 526

here's PROOF of how the GRC method cuts the cost of small parts...

Compare the methods for producing these mutilated gear, cam and bushing combinations . . . for an electrical appliance timer. (Shown actual size.)

* method A	the GRC method
	
* Stamping, screw machine part, assembly • Blanked, pierced, & extruded Cam • Blanked & pierced Gear • Screw Machined Bushing • Sub-assembly: Stake Bushing to Gear • Final Assembly: Stake Cam to Gear	One Piece—One operation Automatically Die Cast of Zinc Alloy A BETTER PRODUCT • Ready to use as cast • Closer tolerances • Higher uniformity • No buckler gears & cams • No loose assemblies • No misalignment (gear-cam orientation . . . critical in this application) SIMPLER PRODUCTION • Cast and trimmed in one automatic step . . . no secondary operations • No scrap loss
5 PRODUCTION STEPS + 5 Inspections	1 PRODUCTION STEP only ONE inspection needed

NOW . . . compare these figures:

Cost/M in lots of	100M	200M	500M	1MM
Method A	$32.50	$31.00	$30.00	$29.50
GRC Method	17.44	15.58	12.50	10.00

CLEAR SAVINGS FROM 50-60%

"BONUS FOR DESIGNERS" Only the GRC Method gives you such *complete design freedom* for small parts. It turns many "impossible-to-make-at-any-price" ideas into uniform, high quality parts . . . at lower cost. So, before you change your design . . . check with GRIES.

You've seen the facts . . . clear proof of how GRC's DIE CASTING METHOD offers substantial savings on your small parts. The Gries Method delivers parts of high uniformity, with close tolerances . . . ready for use as they come from Gries' automatic machines. Assembly and most other secondary operations are eliminated.

Write, wire, phone NOW for GRC's bulletin "Small Die Castings Exclusively"; send prints for quotation.

MAXIMUM SIZE: 1 ¾" long, ½ oz. No Minimum

GRIES

GRIES REPRODUCER CORP.

World's Foremost Producer of Small Die Castings

153 Beechwood Ave., New Rochelle, N. Y. • NEw Rochelle 3-8600

For more information, turn to Reader Service Card, circle No. 395

What's new IN MATERIALS

PROPERTIES OF LAMICOID 4012-42

PHYSICAL PROPERTIES	
Specific Gravity	1.30
Water Absorption, %	0.56
Heat Resistance[a]	No blistering
MECHANICAL PROPERTIES	
Tensile Strength, psi	
Lengthwise	15,000
Crosswise	12,000
Flexural Strength, psi	
Lengthwise	20,000
Crosswise	17,500
Izod Impact Strength, ft-lb/in.	
Lengthwise	1.75
Crosswise	2.14
ELECTRICAL PROPERTIES	
Dielectric Constant (1 mc)	4.2
Dissipation Factor (1 mc)	0.03

[a]Aged 7 sec at 600 F.

and can be punched into intricate parts with conventional equipment. The laminate is said to be suitable for printed circuits and electronic terminal boards.

2. Self-extinguishing grade

The self-extinguishing laminate extinguishes itself within 3 sec after removal from a flame (i.e., 2 sec faster than Underwriters Laboratories requirements).

Called Fireban 321, the laminate has high insulation resistance, low dielectric loss, low water absorption and good fabricating qualities. The material is the first of a new family of flame retardant laminates introduced recently by Taylor Fibre Co., Norristown, Pa.

Field tested as terminal boards for TV transformer assemblies, the material is expected to find use wherever flame retardance is an important consideration. It is supplied in sheets approximately 49 x 49 in., and in thicknesses from 0.020 to ¼ in.

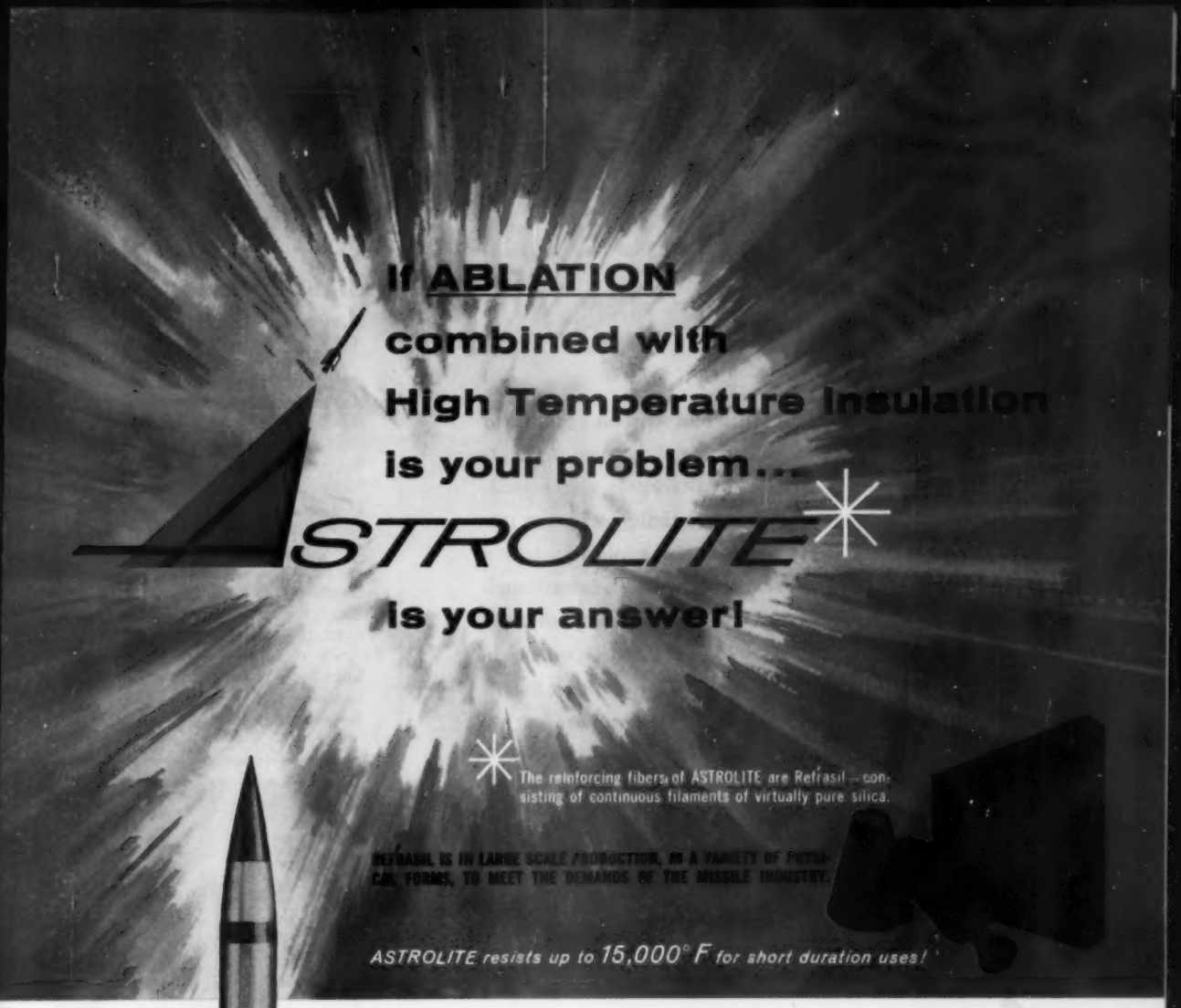
(more What's New on p 158)

PROPERTIES OF FIREBAN 321[a]

Flexural Strength (flatwise), psi	
Lengthwise	17,000
Crosswise	13,000
Water Absorption, %	0.60
Dissipation Factor (1 mc)	0.028
Dielectric Loss (1 mc)	0.126
Insulation Resistance, megohms	250,000

[a]Tests conducted on 1/16-in. specimens.

For more information, circle No. 524


If ABLATION
combined with
High Temperature Insulation
is your problem...
ASTROLITE
is your answer!
The reinforcing fibers of ASTROLITE are Refrasil—consisting of continuous filaments of virtually pure silica.
REFRASIL IS IN LARGE SCALE PRODUCTION, IN A VARIETY OF FISSILE FORMS, TO MEET THE DEMANDS OF THE MISSILE INDUSTRY.
ASTROLITE resists up to 15,000° F for short duration uses!

ite for your copy
the new HITCO
APABILITIES Brochure.

ASTROLITE

Product Bulletin No.
PB7-24 describes its
stonishing resist-
nce to ultra-high-
emperatures. Write
or it today.

If you are a Missile or Spacecraft Designer or Manufacturer—with a need for **ultra-high-temperature materials**, you know the vital importance of **low ABLATION rate.**

ASTROLITE is a remarkable **Refrasil**-reinforced plastic with impressive resistance to Ablation **and** extremely high temperatures—**up to 15,000°F.** for short-duration applications!

Fabrication techniques for ASTROLITE have been perfected to give optimum fiber orientation to resist Ablation—while retaining maximum insulation properties.

Many major airframe and missile manufacturers are using ASTROLITE today in their Space Technology programs.

Perhaps you can use ASTROLITE for insulation of Rocket Nozzles, Nose Cones, Deflector Vanes, Blast Tubes or Combustion Chamber Liners. Engineering counsel is yours for the asking. Please write to Director of Research.

H. I. THOMPSON FIBER GLASS CO.
1733 Cordova Street, Los Angeles 7, Calif. • REpublic 3-9161

WRITE OR CALL YOUR NEAREST HITCO REPRESENTATIVE: EASTERN: Tom Kimberly, 38 Crescent Circle, Cheshire, Connecticut, BRowning 2-6544. Fred W. Muhlenfeld, 6659 Loch Hill Rd., Baltimore 12, Md., VAlley 5-3135 - MIDWEST: Burnie L. Weddle, 1347 Pennsylvania St., Indianapolis 2, Ind., ME 5-5607 - SOUTHWEST: Marshall Morris, 2850A W. Berry, Rm. 14, Fort Worth, Texas, WAlnut 4-8679 - NORTHWEST: J. L. Larsen, 5757 Oaklawn Place, Seattle, Wash., PArkway 5-9311 - CANADIAN PLANT: THE H. I. THOMPSON CO. OF CANADA LTD., 60 Johnston St., Guelph, Ontario. Telephone: TAylor 2-6630

SEAL RING PROBLEMS Solved!

As with most carbon, graphite or molded metal powder products made by Stackpole, recommendation of suitable grades for mechanical seal applications is a matter of careful "custom" engineering. That's where over 50 years of specialized experience in this field really counts. Dozens of Stackpole standard grades are subject to almost infinite variation for either rings or mating members. And Stackpole seal engineers know their way around in determining the best grades for almost any equipment or operating condition.

Send details of your seal ring needs for recommendation.

STACKPOLE

"everything in carbon but diamonds"

LOW-FRICTION Clutch Rings

Stackpole carbon rings frequently replace ball thrust bearings with appreciable cost savings.

STACKPOLE CARBON CO.
St. Marys, Pa.

For more information, turn to Reader Service card, circle No. 487

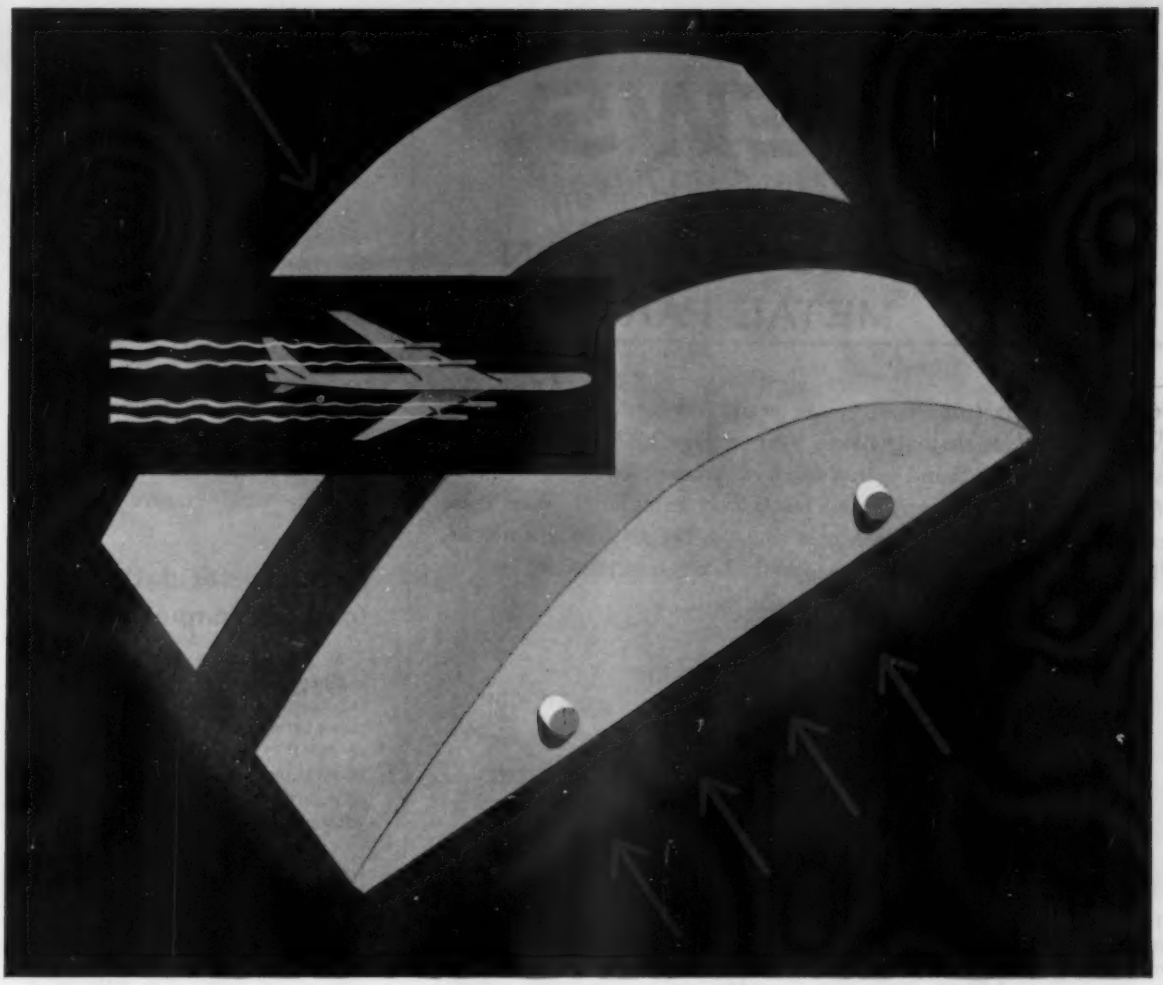
What's new IN MATERIALS

High Strength Steels Have Good Ductility

A new hardening process turns out ultra high strength structural steels (modified 4340) with tensile strengths of more than 400,000 psi combined with excellent ductility. The steels and the process for manufacturing them were developed by Ford Motor Co.'s Engineering & Research Staff, 20000 Rotunda Dr., P. O. Box 2053, Dearborn, Mich.

The steels are said to be equal in toughness to the best ultra-high strength steels now commercially available. Fatigue limit of the new steels is 200,000 psi—about a 30% improvement over present alloys, according to the developer. Ford metallurgists say the high strength of the

Synthetic quartz — An engineer measures the thickness of a synthetic quartz crystal now in pilot plant production at Western Electric's Merrimack Valley Works, North Andover, Mass. In growing the crystals, small pieces of natural quartz are placed in the bottom of an alkaline-filled vessel to provide the nutrient. Seed plates cut from either natural quartz or synthetic crystals are then hung from a rack in the upper section of the vessel. The autoclave is sealed and maintained under a constant temperature from bottom to top. The growing technique is said to turn out crystals measuring ¾ in. square by 1½ in. long.



Save up to 30% in cost, 60% in time with EPON® RESIN tools and dies

Your tooling resin formulator will show you how Epon resin formulations save time and money in applications such as these:

High temperature tooling: Metal forming stretch dies that can operate at temperatures over 400°F.

Heated tools: Matched dies, with integral heating units, may be made with Epon resin formulations for rapid heat curing of laminated plastic parts.

Long-lasting metal forming tools: Castings made of formulated Epon resin, mounted in a crank press, showed no permanent deformation after 28,000 compression-shock cycles.

In addition, Epon resin formulations offer you the following advantages:

Excellent tolerance control: Little machining and handwork are required to finish Epon resin tools because of the material's excellent dimensional stability and lack of shrinkage.

Outstanding strength: Jigs and fixtures with thin cross sections can be built from Epon resin-based formulations reinforced with glass cloth. The resulting laminate has high flexural strength and excellent dimensional stability.

Easy modification: Tools and fixtures made from Epon resins may be quickly and easily modified to incorporate design changes.

CONTACT YOUR TOOLING RESIN FORMULATOR

The combination of resin formulator's skill and practical knowledge, backed by Shell Chemical's technical research and experience, has solved many important tooling problems for industry. Your own formulator specialist can help you solve yours. For a list of experienced tooling resin formulators and additional technical information, write to:

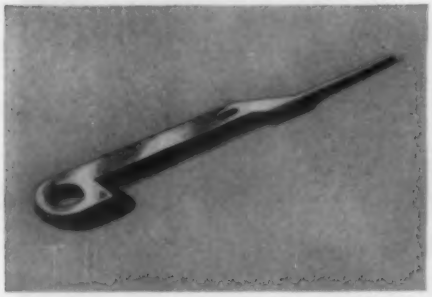
SHELL CHEMICAL CORPORATION
PLASTICS AND RESINS DIVISION
50 WEST 50th STREET, NEW YORK 20, NEW YORK
CHICAGO • CLEVELAND • LOS ANGELES • NEW YORK
IN CANADA Chemical Division, Shell Oil Company of Canada, Limited, Montreal • Toronto • Vancouver

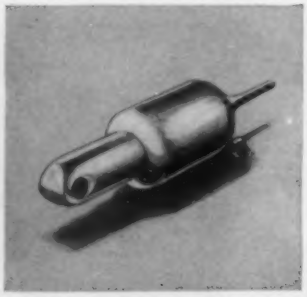
SHELL

For more information, turn to Reader Service card, circle No. 454

NEWS
from Torrington on
SMALL PRECISION METAL PARTS

"Custom manufacture" need not be costly—at least, as practiced at Torrington's Specialties Division. Our engineers, experienced in a multitude of methods and operations, have a knack for fitting the most efficient techniques to any small metal part in question. And these methods are not necessarily the most obvious. The motto might well be, "Precision at any cost—so long as it's the *lowest* cost possible!"

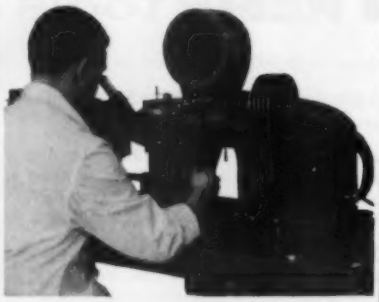




Take the control pin and sensing pin we make for a leading business machine manufacturer. Diameter of the circular section must be held to .001". Other critical dimensions require as stringent tolerances. Torrington selected a combination of stamping and swaging operations as most economical and efficient. High accuracy is achieved without tool marks or stress concentration points. Parts are tempered to RC 52-54, and are accurate to required tolerance *without grinding* and have a better finish than grinding would produce!

Then there's the pin we make for an aircraft application. Made of 440C stainless—a difficult material to work—it is finished to 8 micro-inches, again without grinding. The three radii are held concentric to .006". After tempering to RC 52-60, the part is given a .0002 to .0004" hard chrome plate.

Part of the perfection of the finished unit is the quality of material used. Skilled metallurgists have access to the most modern laboratory equipment to make sure materials meet your drawing specifications. We maintain three separate heat-treating departments, each with equipment selected for specific types of parts or materials involved. Statistical quality control methods insure the quality of product you specify. For help with



your large quantity requirements of small precision metal parts, just circle our number on the reply card, call our area salesman, or write direct to:

The Torrington Company, Specialties Division, 777 Field Street, Torrington, Conn.

TORRINGTON SPECIAL METAL PARTS

Makers of Torrington Needle Bearings

For more information, turn to Reader Service card, circle No. 436

new steels is due in part to extremely fine grain size.

How process works

In essence, the hardening process consists of plastically deforming metastable austenitic steels above the martensite temperature, then transforming them to martensite. Initial experimental studies were confined to steels with a modified 4340 composition. Other steels are currently being evaluated.

Urethane Insulation for Low Temperatures

A polyurethane foam insulation has been developed for low temperature applications. Because of its low thermal conductivity (0.12 Btu/hr/sq ft/°F/in.), the insulation is said to increase the usable interior space of a refrigerator by as much as 50% without enlarging the exterior.

A product of Pittsburgh Plate Glass Co., 632 Fort Duquesne Blvd., Pittsburgh 22, the insulation is made of polyester resins and halogenated hydrocarbon blowing agents (Freon) which are entrapped in the individual cells of the foam. The material is called Selectrofoam.

According to the producer, 1¼ in. of the foam have an insulating efficiency equal to that of 3 in. of conventional insulation. Other advantages of the foam insulation are: 1) it adheres to a variety of materials; 2) it has good sound dampening properties; 3) it eliminates the need for many bracing operations; 4) it is non-friable; and 5) it requires fewer square feet of outside paneling for a given cubic content.

In addition to refrigerators, the insulation is expected to find use for cold storage rooms, refrigerated trucks and trailers, and building panels.

Sintered Glass Fuses Directly to Copper

A pressed and sintered glass has been developed that can be directly sealed to copper. The glass has a coefficient of thermal expansion (8.6

IN PRODUCT AFTER PRODUCT AFTER PRODUCT
. . . WEIRTON HOT- AND COLD-ROLLED SHEET

In automobiles and portable TV cabinets, in air conditioners, stoves and laundry equipment—in almost any application you can name you'll find Weirton hot- and cold-rolled sheets at work.

Their roles: helping one manufacturer after another to produce standout products at low cost with no hitches in fabrication.

You can put to good use the uniform gauge, strength and ductility of Weirton hot- or cold-rolled sheet.

Weirton is always ready to serve your needs for quality sheets. For prompt and complete service just phone or write Weirton Steel Company, Dept. E-3, Weirton, West Virginia.

WEIRTON STEEL COMPANY

WEIRTON STEEL COMPANY
WEIRTON, WEST VIRGINIA
a division of
NATIONAL STEEL CORPORATION

For more information, turn to Reader Service Card, circle No. 422

Chace THERMOSTATIC BIMETAL

ACTUATES ANOTHER PRECISION PRODUCT

The Precision Controls MOTOR PROTECTOR

More and more, our modern existence demands motor driven home appliances, ventilating equipment, automobile accessories and features and industrial mechanisms of all types. Precision Controls Company provides a tiny but effective device which protects such electric motors, both the intermittent and continuous service types, against burnouts. The bimetal element in the miniature snap-action breaker shown is so calibrated as to be responsive to electrical overloads caused by high power demands on the motor. The bimetal will also sense an abnormal rise of ambient temperature inside the motor, opening the contacts before damage is done to the motor. The precision element, of course, is Chace Thermostatic Bimetal.

Precision Controls says, "The wide range of Chace Bimetals makes our job that much easier in applying them to the wide range of requirements needed by the motor manufacturers." There was no need to mention Chace's uniformity — of alloys, of processes which create the many combinations of alloys, of precision tolerances. Absolute predictability of response, dependent on such uniformity, causes the millions of users of automobiles, appliances and machines to buy again and again without hesitation although few know of the years of development and engineering behind our precision products and our customers'. Their confidence proves our third of a century as manufacturers of thermostatic bimetal has been well spent.

While your new temperature-responsive device is in its early design stages, remember that Chace Thermostatic Bimetal is available in over 30 standard types and many specials to suit any requirement. It is also available fabricated and assembled into elements of your design or in strips or coils. Send for our booklet, "Successful Applications of Chace Thermostatic Bimetal," containing engineering data.

IT BENDS WITH THE HEAT

W. M. CHACE CO.
Thermostatic Bimetal
1615 BEARD AVE., DETROIT 9, MICH.

For more information, turn to Reader Service Card, circle No. 482

What's new IN MATERIALS

***Leads** made with Corning's new glass are sealed directly to copper base of these electronic parts without using metal eyelets.*

x 10^{-6}/°F) closely matching that of copper (9.5 x 10^{-6}/°F). Heretofore, copper-to-glass seals were made by beading the glass on a scarfed edge of copper.

Corning Glass Works, Corning, N. Y., developer of the glass, has designated it Code 7295 copper sealing Multiform. The glass is expected to find use in electronic parts.

Working point of the glass is 1200 F; softening point is 870 F; annealing point, 690 F; and strain point, 650 F. Volume resistivity is 6.7 ohm-cm at 480 F and 5.0 at 660 F.

The material is made from small glass particles pressed to shape and then fired at high temperatures. The particles are then fused into a nonporous, vacuum-tight structure.

Two Electroplates for Zinc Die Castings

Marked improvement in the corrosion performance of electroplated zinc die castings has resulted from the development of two new plating systems. William H. Safranek, speaking before a joint meeting of the American Electroplaters' Society and the Society of Die Casting Engineers last fall, reported that the systems are already being used to plate some automotive hardware parts. Research on the plating systems (sponsored by the American Zinc Institute) was conducted at Battelle Memorial Institute.

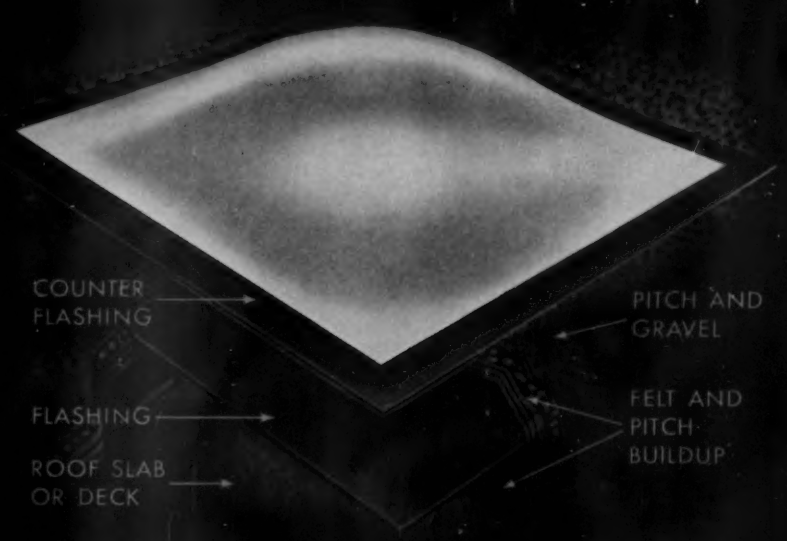
Copper-nickel-chromium

The first of the systems described is a modification of the conventional copper-nickel-chromium system in which a thicker-than-normal chro-

For more information, circle No. 478 ➤

Consolite

self-flashing
double dome skylights



Consolite skylights are manufactured by Consolidated General Products, Houston, Texas.

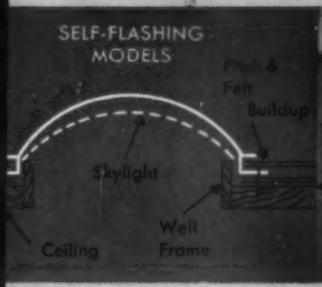
New double-dome concept in skylight engineering . . .

using glass fiber-reinforced

CELANESE POLYESTER RESIN

. . . exhibits

- Good light transmission and diffusion with less heat conductivity and little condensation . . .
- Excellent strength and durability; good resistance to weathering, rust, and corrosion; and . . .
- Light weight, which with one-piece, self-flashing design lowers material, shipping, and installation costs . . .



Cross section showing double dome and self-flashing features of Consolite skylights.

Easily installed as integral part of roof. Especially adapted to built-up roofs.

More skylights, more light. Glass-reinforced polyester resins are natural light diffusers.

MobilDome skylights on trucks provide light for loading, unloading.

. . . A combination of all these advantages features the remarkable Consolite skylights that are made with (and made possible by) glass fiber-reinforced Celanese polyester resin. According to the manufacturer, only reinforced polyester resins, adapted to his unique design, can provide this *complete* combination.

The material's good diffusion properties combined with double-dome design provide better light and at the same time excellent insulating properties. Condensation is lessened. The dome exhibits excellent load bearing properties, good strength and shatter-resistance over a wide temperature range and is easily repairable if damaged. Consolite domes also resist rust and corrosion.

If you'd like to investigate how a remarkable combination of properties and performance characteristics might be teamed with an unusual design idea you may have for your product, write Celanese for information about reinforced polyester resins. Celanese Corporation of America, 180 Madison Ave., N. Y. 16. Canadian Affiliate: Canadian Chemical Company Limited, Montreal, Toronto, Vancouver. Export Sales: Amcel Co., Inc., and Pan Amcel Co., Inc., 180 Madison Ave., N. Y. 16. Celanese®

Celanese polyester resins

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Whatever your needs in technical glass components—Kopp Glass has the engineering staff, modern laboratories and manufacturing facilities to meet them. If you require parts with certain light and color transmission, beam control, thermal shock resistance, mechanical strength, dimensional uniformity or other properties—Kopp technicians can supply them to your exact specifications.

To meet specific application requirements, Kopp engineers develop a formula of the actual ingredients to provide the finished part with the desired properties . . . design the mold in which molten glass is pressed to exact physical dimension . . . and establish rigidly-controlled manufacturing procedures.

What's your problem? Perhaps we could design a part for you in glass that would solve a problem or improve your product. If you are interested, we'll be glad to discuss it with you.

KOPP GLASS SPECIALISTS IN TECHNICAL GLASS GLASS

Kopp Glass INC.

SWISSVALE, PENNSYLVANIA

For more information, turn to Reader Service card, circle No. 438

mium plate (0.000025 in.) is deposited crack-free and pore-free.

Accelerated corrosion and outdoor weathering tests on die castings plated by this process show they have a two to three-fold increase in corrosion resistance over conventionally plated castings. The greater resistance is attributed to the increase in the chromium thickness combined with appropirate control of plating conditions.

Duplex nickel

The second plating system described is a duplex bright nickel system in which castings are plated with two layers of nickel in different baths. Plating conditions are adjusted so that 1) the first, thicker layer is passive to corrosive environments, and 2) the second, bright layer requires no buffing. The bright nickel electroplate is said to be more active chemically than dull or semi-bright nickel electroplates.

Investigations show that the system furnishes much more corrosion protection to zinc die castings than an equal thickness of a single bright nickel layer.

Other developments

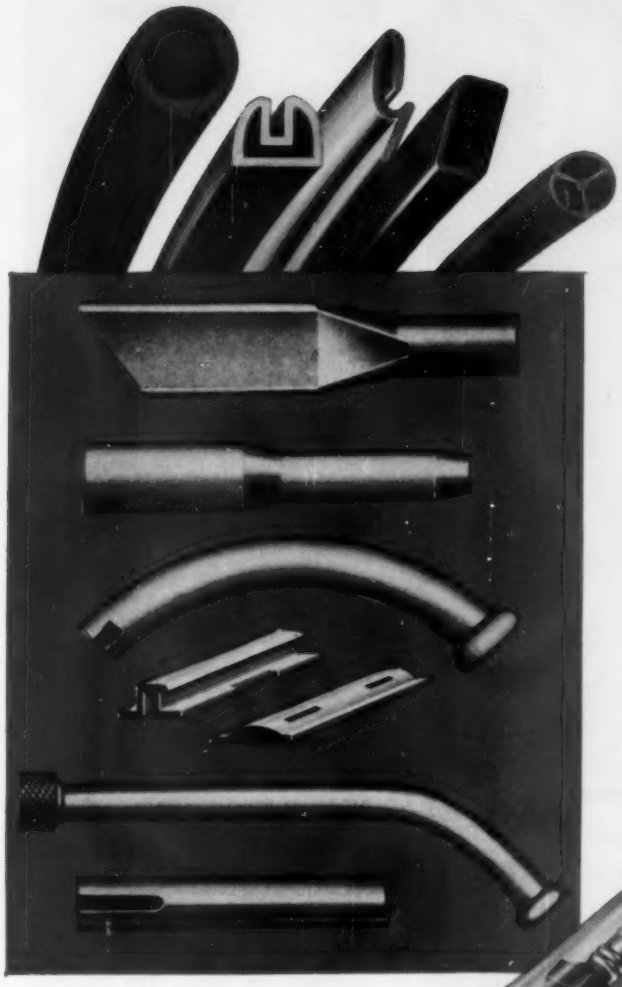
Safranek also described research now under way at Battelle for improving finishing processes. Included in this research is a process for electropolishing zinc die castings and a process for plating zinc with excellent leveling power. Completion of these developments, he says, would open up possibilities for eliminating the buffing operation that currently is necessary before plating with copper, nickel and chromium.

Asbestos-Filled Plastic Is Strong at 500 F

An asbestos-filled diallyl iso-phthalate (DAP) plastic retains a flexural strength of 1800 psi, a compressive strength of 6000 psi, and a tensile strength of 4300 psi after prolonged exposure to temperatures up to 500 F.

Other advantages include: 1) good electrical properties; 2) good dimensional stability; 3) good resistance to acids, alkalis, solvents, fuels and corrosive chemicals; 4) low mold

Consult YARDLEY for:



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TUBING—in special shapes or standard, rigid or flexible in diameters from ⅛" to 16".

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ready for your production line

We shape, flatten, curve, swedge, drill and perform many other fabricating operations to make your plastic parts ready for use. Close tolerance, absolute uniformity, dimensional stability and high-gloss finish are standard production requirements at Yardley.

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This smart package for the protection of spark plugs from dirt and moisture is made of extruded polyethylene tubing. Heat sealing operation is performed automatically on a machine especially designed by Yardley engineers. We may have the solution to your packaging problem. Write us today.

Rigid and Standard Polyethylene
Rigid and Elastomeric Vinyl • Acrylic
Cellulose Acetate • Cellulose Butyrate
Kralastic • Styrene • Nylon • Cycolac
Ethyl Cellulose

Our complete tool and die shop is staffed with skilled technicians. In addition, we maintain a library of over 300 section dies, one of which may fit your product design.

YARDLEY PLASTICS CO.
142 PARSONS AVE., COLUMBUS 15, OHIO

YARDLEY MAIL COUPON FOR MORE INFORMATION

Yardley Plastics Co.
142 Parsons Ave., Columbus 15, Ohio

I am interested in learning how you can help us find better ways to solve our extruded plastics problems.

Name_____
Company_____
Street_____
City_____ Zone____ State_____
Position_____

For more information, turn to Reader Service card, circle No. 499

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range panels of Lancaster glass add sales appeal, beauty and utility
For the designer, glass is a truly dynamic material. It offers low tooling cost, an unlimited range of colors, and wide fabricating flexibility. Its sanitary, heat-resistant characteristics mean brighter living, easier housekeeping for the homemaker.
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Lancaster glass
to brighten your product's future.

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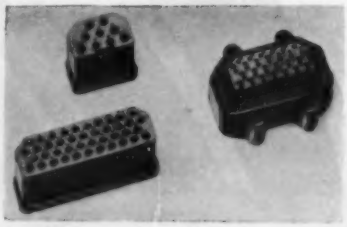
What's new IN MATERIALS



***Electrical parts** molded of a heat resistant, asbestos-filled DAP plastic.*

shrinkage; and 5) low weight loss at high temperatures.

The compound, called Diall FS-6, is now commercially available from Mesa Plastics Co., 11751 Mississippi Ave., Los Angeles 25. The material sells for $1.25 per lb.

According to the producer, Diall FS-6 does not require extra long cure time or afterbakes, and can be handled and cured like any mineral-filled, general purpose material. It is recommended as an insulating material for such electrical devices as connectors and switches.

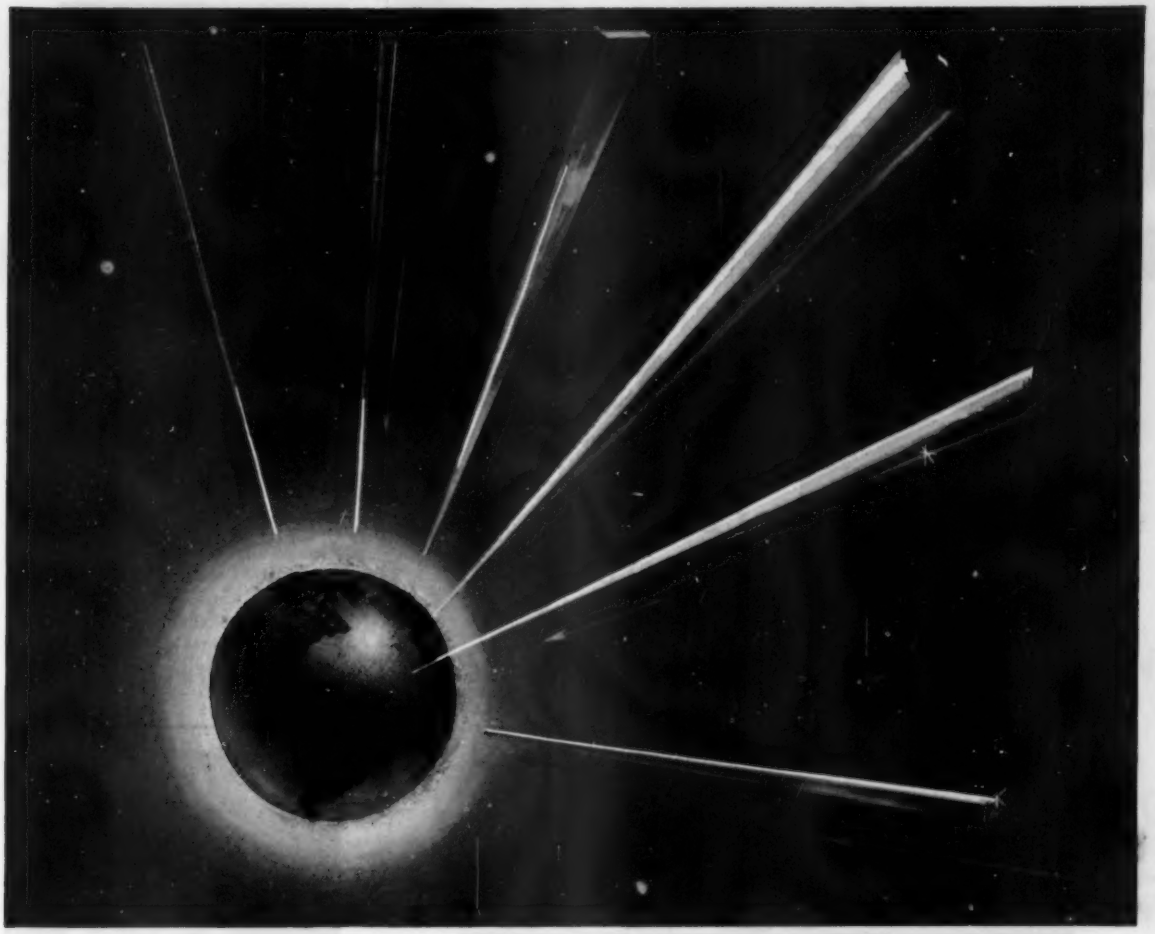
Nickel-Base Alloy Sold as Sheet, Bar, Castings

Additional information on suppliers of René 41 (a nickel-base sheet alloy) in sheets, bars, billets and investment castings is given in the accompanying table. The information was obtained from R. J. Morris, Materials Specialist, General Electric Co., Aircraft Gas Turbine Div.,

SUPPLIERS OF RENÉ 41•

Form →	Sheet	Bar	Billet
Allegheny Ludlum Steel Corp.	X	X	X
Cannon-Muskegon Corp.	X	X	X
Crucible Steel Co.	X		
Firth Sterling, Inc.		X	
General Electric Co., Metallurgical Products Dept.	X	X	X
Haynes Stellite Co., Div. of Union Carbide Corp.	X		
Kelsey-Hayes Co., Utica Metals Div.	X	X	
Universal-Cyclops Steel Corp.	X	X	X

•Suppliers of investment castings: 1) Haynes Stellite Co., Div. of Union Carbide Corp.; 2) Crucible Steel Co.; and 3) Austenal, Inc.



Let's get down to earth about Exotic Metals!

Do you think titanium, zirconium, columbium, tantalum and other exotic metals are "out of this world" for your use?

You may be mistaken. Today the picture is changing. Increased demand and new production techniques are fast bringing their cost and availability *down to earth* for many commercial applications.

In fact, many companies are finding that their use often more than compensates for their extra cost in unparalleled corrosion resistance at high temperatures, better performance and longer service life.

If you have special problems of heat or corrosion resistance...a difficult application that demands unusual mechanical, physical, structural or nuclear properties...these metals deserve careful consideration. And Bridgeport is ready to help you use them.

LOOK INTO THE BRIDGEPORT METALS DEVELOPMENT PLAN

Bridgeport has pioneered in fabricating mill products from exotic metals from the start and has produced many miles of special metals tubes. We have originated many of the processing methods that are daily transforming these metals from costly rarities to readily available materials in a variety of forms—tube, rod, sheet and extruded shapes. This represents a substantial investment in time, skill and equipment. Because of our confidence in the rapid progress of exotic metals technology, we are prepared to work with you in their application on a cooperative basis. We welcome the opportunity to help solve your most difficult application problems. The coupon will bring prompt action. Send it today.

Dept. 8501, BRIDGEPORT BRASS COMPANY, Bridgeport 2, Conn.
Please send information on the BRIDGEPORT SPECIAL METALS DEVELOPMENT PLAN.

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Company_____

Address_____

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Bridgeport Brass Co.

BRIDGEPORT BRASS COMPANY

BRIDGEPORT 2, CONNECTICUT

*Specialists in Metals from **A**luminum to **Z**irconium*

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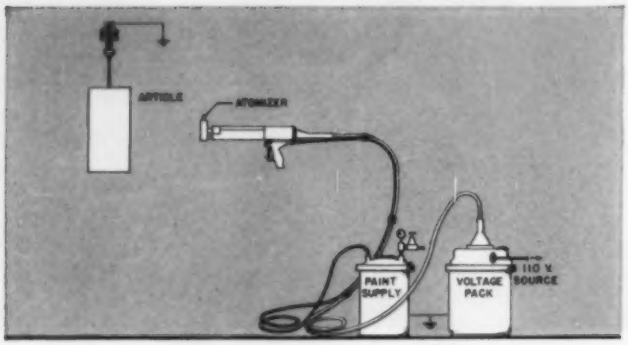
The PAINTING TOOL ALL Industry has been waiting for!

The NEW

RANSBURG

NO. 2 PROCESS ELECTROSTATIC HAND GUN



CUTS PAINTING COSTS!

Saves Paint because there's no waste. Now, for the first time, the high efficiency of Ransburg's No. 2 Process automatic equipment is available to you in the NEW Electrostatic Hand Gun.

Saves Labor, Increases Production because it is faster on many types of articles such as those fabricated from perforated and expanded metals, tubing, rod and wire. This is due to the "wrap-around" nature of electro-spray which paints ALL sides of such articles from one side only.

Saves in Equipment because no conventional spray booth is required—no water-wash, no sludge recovery! Uses no compressed air for atomization.

Saves Building Heat Loss because only mild ventilation for removal of solvent vapors is necessary, and . . .

Maintenance Costs Are Cut because clean-up and maintenance labor is only a fraction of that required by other, less efficient painting methods.

See how YOU can save in your own finishing department, and at the same time, improve the quality of the work. Write for literature and information showing how the Electrostatic Hand Gun has been proven on different products in a variety of industrial plants.

Call or write

RANSBURG Electro-Coating Corp.

Box-23122, Indianapolis 23, Indiana

For more information, turn to Reader Service card, circle No. 496

Cincinnati 15, Ohio.

Morris says a license is not required when the material is supplied to the government for defense applications. (For information on the properties and uses of René 41, see M/DE, Nov '58, p 143.)

Ferromagnetic Parts Usable up to 660 F

Two new high temperature ferromagnetic materials have been used successfully as antenna couplers at intermittent service temperatures up to 660 F. Cores of these materials changed less than 10% in Q and magnetic permeability after 100 hr at 530 F under normal atmospheric

Vibrating matter — Scientist vibrates the atoms of a crystal up to 20 million times a second in a small metal box placed between the poles of a large electromagnet.

The technique, known as "nuclear magnetic resonance acoustic absorption," takes advantage of the fact that the nuclei of atoms resemble tiny spinning magnets. These nuclear magnets have north and south magnetic poles—comparable to the poles of a compass needle—which tend to line up parallel with one another when placed between the poles of a magnet. Vibration supplies enough energy to affect the spinning nuclear magnets, thereby upsetting the atoms' magnetic balance. Unbalance is detected through electrical signals that show the interaction between the atomic nuclei and the electrons swarming around them.

The technique was discovered recently at Westinghouse Research Laboratories.

Tool Steel Topics

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

TO ALL TOOL AND DIE MAKERS:
BETHLEHEM ANNOUNCES AIR-4, A NEW FREE-MACHINING TOOL STEEL WHICH AIR-HARDENS AT LOW TEMPERATURE STOP AIR-4 HAS EXCELLENT FREE-MACHINING CHARACTERISTICS BECAUSE OF ADDITION OF LEAD STOP OTHER OUTSTANDING PROPERTIES INCLUDE EXCELLENT WEAR RESISTANCE AND HIGH TOUGHNESS FOR GENERAL-PURPOSE TOOLING STOP AIR-4 IS A DEEP-HARDENING GRADE AND HARDENS AT ABOUT 1550F STOP OTHER ADVANTAGES INCLUDE 1. SAFE HARDENING 2. MINIMUM SIZE CHANGE DURING HEAT-TREATMENT
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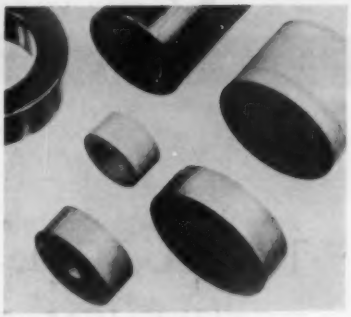
What's new IN MATERIALS



***Typical parts** made of new ferromagnetic materials.*

conditions.

Known as Ferrotron, the ferromagnetic materials are products of Polymer Corp. of Pennsylvania, 2140 Fairmont Ave., Reading, Pa. Production quantities are normally supplied as molded parts; standard shapes are also available for machining of prototypes.

The materials are said to extend the operating range of cores from 165 to 300 °F. They have a volume resistivity greater than 10^{m} ohm-cm and high dielectric strength. Cores made of the materials are said to have impact strengths up to 50 times greater than conventional cores, with properties unaffected by moisture and aging.

Leaded Steel Tubing

A leaded steel tubing is now available from Joseph T. Ryerson & Son, Inc., Box 8000-A, Chicago 80. The product is a cold drawn seamless steel tubing of low carbon content with 0.15 to 0.35% lead added.

Designated Ledloy 170, the tubing can be machined at 170 fpm (surface speeds), compared with 100 to 120 for MT-1015 tubing. The company says that a minimum increase of 25% in the production of machined

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COOPER ALLOY CASTINGS BRIEFS

THE CASTINGS ANSWER CORNER

Carl Tylka, Cooper Alloy Technical Service Director, answers your questions on stainless steel castings

Q. *Cooper Alloy has recently publicized the production of stainless castings having higher physical properties than required by code. Does this result in any economies in construction?*

A. Yes, definitely. For ASME Boiler and Pressure Vessel Code designs, the casting's higher strength will increase the inherent design safety factor. For non-code designs, the higher strengths will make possible lighter wall sections. Both these features will make for more economical use of materials.

Q. *Does magnetism in an 18-8 stainless steel mean that the material's composition falls outside the normal specification range?*

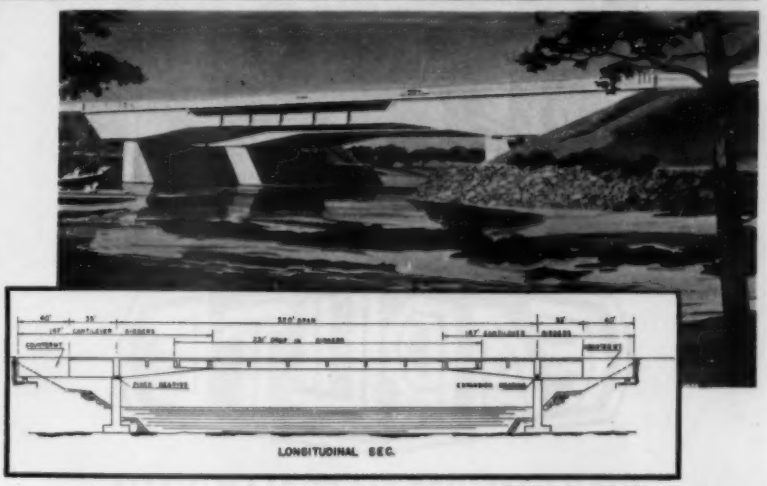
A. No. Magnetism of an 18-8 stainless depends on its ferrite content, which is variable within the boundaries of composition specs (e.g., ASTM A351, Grade CF8), and may be estimated by Schaeffler's method. Magnetism can be controlled through both chemical composition and heat treatment.

Q. *Shrink in stainless castings seems to be a common fault. Can it be avoided so as to make repair welding unnecessary?*

A. Yes, casting shrink can be avoided by proper mold design which allows for optimum metal flow, heading, and gating, and which provides progressive solidification through use of predetermined drafts or tapers. We do it all the time at Cooper Alloy.

Q. *Can ultrasonic testing give as reliable results as do X-Rays in quality control of stainless castings?*

A. No. Ultrasonic testing of stainless castings is not a feasible quality control method at present, because of difficulties of test interpretation. The inherent large grain structure of castings does not lend itself to this type test. To date, no satisfactory correlation or basis of interpretation of ultrasonic tests has been devised.



Cast Stainless Steel Bearings and Bearing Plates To Be Used on Nation's Longest Post-Tensioned Concrete Bridge Span

Will eliminate maintenance, provide long-range economies

Some 175,000 lbs. of machined Cooper Alloy stainless castings will soon be in use as bearings and bridge plates, on the longest post-tensioned concrete bridge span in the Western Hemisphere: the Oneida Lake Bridge on New York's Empire Stateway, now under construction at Brewerton, N. Y. Bridge spread is 470 ft. between abutments, with center span of 320 ft.

Normally such elements are made of carbon steel, but stainless was found by the designers, Summers & Munninger of Albany, N. Y., to provide two major advantages: greater strength per pound, which permits better load handling in the limited space available; and complete elimination of maintenance. Latter alone will save New York State hundreds of dollars annually in painting and upkeep, and allow the entire cost of the castings to be amortized in 8-10 years.

The stainless bearings, 20 in all, will allow for bridge expansion and contraction under varying weather conditions. Located between girders and piers, and between girders and abutments, they are of three types: abutment bearings (18″x9″x9″) at each end of the bridge; expansion bearings (33″x40″x11″) at the north pier; and fixed bearings at the south pier. Alloy used was ASTM A296-55, Grade CA-15 (12%Cr), having a min. tensile of 90,000 psi, and min. yield of 65,000 psi.

This unusual application of stainless steel castings is but one illustration of the many ways in which a creative adaptation of stainless castings can solve a perplexing equipment and maintenance problem. For further information on what stainless castings can do for you, write to Technical Service Department, Cooper Alloy Corporation, Hillside, New Jersey.

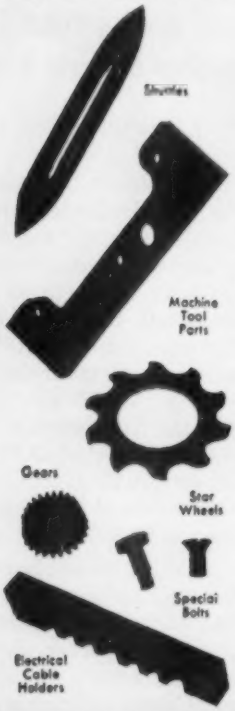
For more information, turn to Reader Service card, circle No. 527

FREE

CHART LISTS THE CHARACTERISTICS FOR 34 STANDARD GRADES OF

FARLITE

HIGH PRESSURE PLASTIC LAMINATES



Here's a handy chart listing the grades, mechanical properties, and electrical properties of Farlite paper and fabric base laminates for easy reference plus suggestions for their best use. In addition, Farlite engineers are always available to help you select the right stock for your requirements.

New Farlite grades are being constantly researched for special applications. If your design or production problems are in this category, ask for complete data sheets.

WRITE today for your free copy of this handy reference chart!

FARLITE

PLASTICS DIVISION
FARLEY & LOETSCHER MFG. CO.
DUBUQUE, IOWA

For more information, turn to Reader Service card, circle No. 532

parts could be expected when Ledloy 170 tubing is substituted for non-leaded tubing.

Phenolic-Fiberglass Is Strong at 600 F

A pre-impregnated glass cloth using a heat resistant phenolic resin as the impregnant is said to retain its strength and modulus at temperatures up to 600 F for extended periods of time. According to the developer, the material can withstand higher temperatures for relatively short periods of time.

Called V-204, the pre-impregnated material is now being marketed by Eli Sandman Co., 280 Greenwood St., Worcester, Mass. Typical parts that may be fabricated from the material include flame barriers; base sheets for printed circuits; antenna housings; flare cases; hot air ducts and baffles; missile noses, bodies and fins; plastics pipe and couplings; rotor blades, spacers and rings; rocket nozzles, insulators, diffusers and chambers; terminal strips; telemetering windows; missile and rocket motor guidance vanes; fuel tanks;

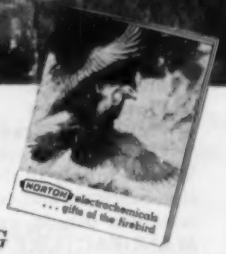
PROPERTIES OF V-204 LAMINATE

PHYSICAL PROPERTIES	
Specific Gravity	1.91
Flammability, in./min	Self-extinguishing
Water Absorption (24 hr), %	0.11
ORIGINAL MECHANICAL PROPERTIES	
Tensile Strength, psi	63,000
Compressive Strength, psi	50,000
Flexural Strength (flatwise), psi	82,000
Flexural Modulus, psi	4.3×10^6
Barcol Hardness	80
AFTER HEAT AGING AT 500 F[a]	
Tensile Strength, psi	52,900
Flexural Strength, psi	55,000
Compressive Strength, psi	37,000
AFTER HEAT AGING AT 600 F[b]	
Flexural Strength, psi	45,000
Flexural Modulus, psi	3.1×10^6
AFTER IMMERSION IN WATER[c]	
Tensile Strength, psi	62,500
Compressive Strength, psi	50,000
Flexural Strength (flatwise), psi	80,000
AFTER IMMERSION IN HYDRAULIC OIL[d]	
Change in Weight, %	0.09
Change in Thickness, %	0.00
Flexural Strength, psi	85,000

[a]Aged ½ hr. [c]Aged 30 days.
[b]Aged ½ hr. [d]Aged 24 hr.

The legendary Firebird, the Phoenix, rose young and strong again and again from flames . . . This is the new Norton Firebird — symbol for the exciting new fused materials made in Norton's electric furnaces.

TITANIUM: gift of the Firebird



Legends relating how rebirth in fire gave the Phoenix newer, greater powers contain a striking symbolism of modern fact.

For Norton electrochemicals are raw materials transformed by electric furnaces into new compounds, with new characteristics.

Titanium, for example, is a metallic element which resembles silicon in some respects. Discovered in 1789, this basic material is now revitalized in Norton electric furnaces. Results are titanium di-boride, titanium carbide, titanium nitride, titanates and other compounds.

While all applications for these high-melting compounds are yet to be found, these materials have proved valuable as source materials, as components of cermets, as metallurgical additives and as electrical conductors.

The wide variety of Norton electrochemicals is worth investigating for their potential value to your own production.

Gifts of the Firebird: compounds of silicon • zirconium • boron • aluminum • magnesium • titanium • chromium . . . including many borides • carbides • nitrides • oxides

FREE CATALOG

For a complete list, with detailed descriptions, write for the new booklet, *Norton Electrochemicals . . . Gifts of the Firebird* to NORTON COMPANY, Electro-Chemical Division 951 New Bond St., Worcester 6, Mass.

NORTON
ELECTROCHEMICALS

MAKING BETTER PRODUCTS . . . TO MAKE YOUR PRODUCTS BETTER

For more information, turn to Reader Service card, circle No. 412

RIGID CR-39 OPTICALLY CLEAR PLASTIC SHEETS

It's superior to any other plastic! If you need an optically clear, rigid, thermosetting plastic sheet that looks like plate glass yet is half the weight, specify CR-39—has greater resistance to impact, crazing, chemicals, acids, wear, abrasion and weathering. Here are some of the hundreds of uses for this amazing plastic:

- Protective lens for welding helmets
- Instrument dials, panels and windows
- Plastic mirrors
- Plotting surfaces
- Photographic filters
- Marine windows
- Safety guards and goggles
- X-ray equipment and accessories
- Projection slides

We can supply in sheet form, thicknesses from .020 to .500, or precision-fabricate and cut to your exact needs. Write or phone today for complete details, specifications and samples of CR-39. WE ALSO MANUFACTURE EVR-KLEER RIGID CAST ACRYLIC PLASTIC SHEETS AND OTHER SPECIAL FORMULATIONS.

CAST OPTICS CORPORATION

552 Newman St.
Hackensack, N. J.
HUbbard 9-4000

Manufacturers of EVR-KLEER* Rigid Plastic Sheets

EVR-KLEER* Registered Trademark of Cast Optics Corp.

For more information, turn to Reader Service Card, circle No. 377

What's new IN MATERIALS

radomes; and honeycomb structures.

The impregnated glass cloth is said to have a storage life of at least 6 months under proper conditions.

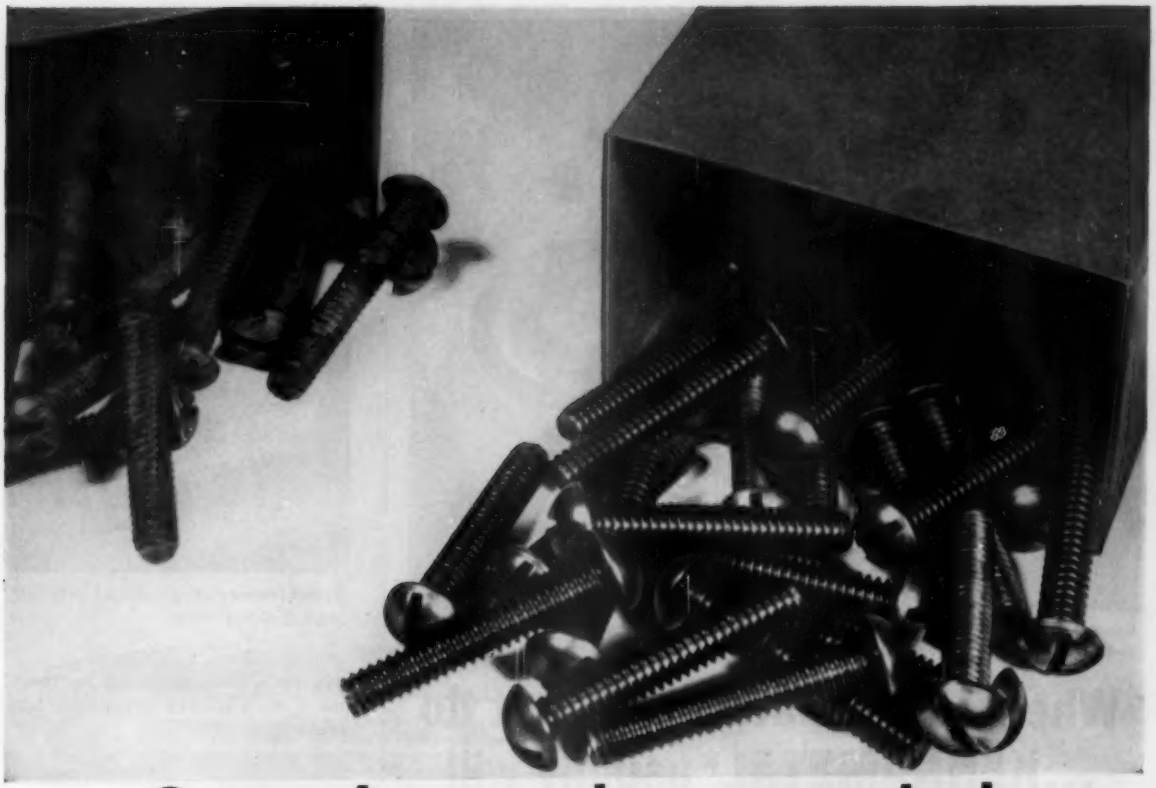
Silicone-Modified Resin Passes Humidity Tests

A silicone-modified, filled encapsulating resin has been designed for use in treating electronic components that require high moisture resistance and flame retardance. Transformers encapsulated with the new resin have passed severe humidity and flammability tests, giving greater reliability. The result: savings in weight, space and most costs, compared with casting techniques.

The resin, designated Fosterite SFR BT-3199, was developed by Micarta Div., Benolite Plant, Westinghouse Electric Corp., Manor, Pa.

(continued on p 176)

Dust-free TV tube—Through the development of a new method of glass lamination, Corning Glass Works, Corning, N. Y. has introduced the shatterproof, dust-free contoured twin panel TV tube shown here. The tube consists of a second contoured glass face panel laminated permanently to the original bulb, eliminating the need for the present front safety plate. Bonding is done by casting a liquid plastic (developed by Rohm & Haas Co. and Dow Chemical Co.) between the surfaces to be laminated. No pressure is required, and only moderate heat.



Corrosion can be prevented with SOLVAY SODIUM NITRITE

Even the finely machined, threaded surfaces of tiny screws can be kept free of rust by treating them with SOLVAY® Sodium Nitrite!

These screws are identical with one important *exception*. The contents of the right-hand box were dipped in a low cost .1% concentration of SOLVAY Sodium Nitrite to form an invisible gamma oxide protective film that guards metal surfaces against corrosion. This easy treatment works equally well on big metal parts—iron or steel sheets, tubes, bars or semi-finished parts during storage or between processing steps. Spray or dip it on, in solution—add it to circulating water systems—combine it with phosphates for greater moisture resistance. In addition, it is reported to suppress degradation in aluminum, tin, monel, copper and brass.

Get the details about the many anti-corrosion uses of SOLVAY Sodium Nitrite and a test sample...

Sodium Nitrite • Calcium Chloride • Chlorine • Caustic Soda • Caustic Potash Chloroform • Potassium Carbonate • Sodium Bicarbonate • Methyl Chloride Soda Ash • Ammonium Chloride • Methylene Chloride • Monochlorobenzene Vinyl Chloride • Para-dichlorobenzene • Ortho-dichlorobenzene • Ammonium Bicarbonate • Carbon Tetrachloride • Snowflake® Crystals • Hydrogen Peroxide Aluminum Chloride • Cleaning Compounds • Mutual® Chromium Chemicals

Allied Chemical

SOLVAY PROCESS DIVISION
61 Broadway, New York 6, N. Y.

SOLVAY branch offices and dealers are located in major centers from coast to coast.

SOLVAY PROCESS DIVISION
ALLIED CHEMICAL CORPORATION
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EP-29

Please send me without cost:

☐ Test sample of SOLVAY Sodium Nitrite

☐ Booklet—"Sodium Nitrite for Rust and Corrosion Prevention"

Name_____

Position_____

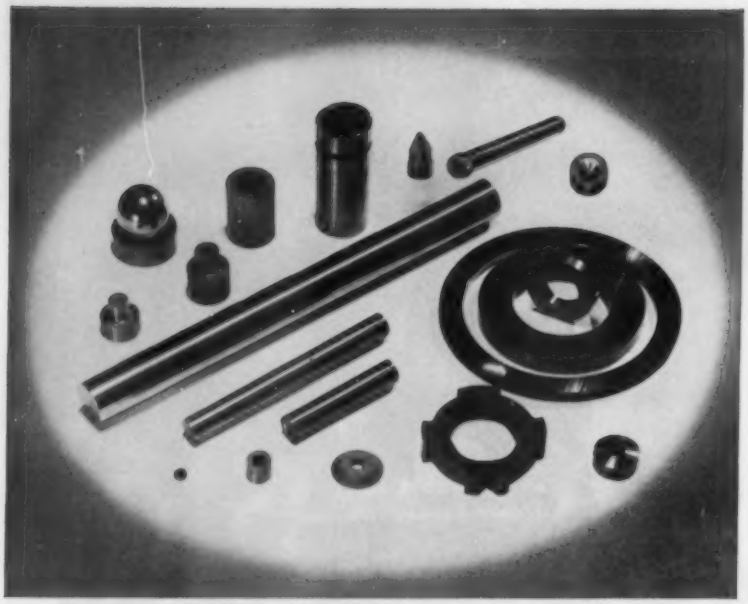
Company_____

Phone_____

Address_____

City_____ Zone____ State_____

For more information, turn to Reader Service card, circle No. 516



Kennametal can be supplied as standard rectangular blanks, discs, rods, tubes, flats, balls, rings . . . and can be extruded, pressed, machined or ground . . . to precise tolerances for specific requirements.

When other materials won't do ...KENNAMETAL* usually will

High hardness and strength; resistance to abrasion, corrosion and high temperatures set Kennametal hard carbide alloys apart from all other design materials.

- Kennametal has an extremely high YME . . . up to 94 million psi compared to steel's 30 million.
- Some grades of Kennametal have a density as high as 15.5 gms/cc . . . twice that of heat treated steel . . . while other grades stand up for days in boiling 5% HNO_3 and 5% H_2SO_4.
- Kennametal is extremely hard . . . up to 94.7 Rockwell A.
- Kentanium,* a series of hard titanium carbide alloys, retains sufficient strength for many applications at temperatures as high as 2200°F.

Very broad applications have been found for these remarkable characteristics: long-wearing plungers, compressor cylinder liners, seal rings for rotary pumps, bushings, valve parts, high temperature sensor elements and hundreds of other critical component parts are being made from Kennametal.

Pushing design frontiers ahead means forcing back the barriers of wear, pressures and temperatures. As man's imagination continues to develop ideas, new problems are encountered . . . for which Kennametal often has the answer. For example, here's how a pump manufacturer recently used Kennametal: problem—to obtain a large pumping capacity from a small pump . . . without increasing pump size. Solution—use Kennametal for critical operating parts to permit faster pump speeds and higher pressures. A simple answer, but made possible only by the great wear- and corrosion-resistant characteristics of Kennametal.

Perhaps Kennametal can solve one of your problems. If you'd like more information, just write Department MDE, KENNAMETAL INC., Latrobe, Pennsylvania.

5760

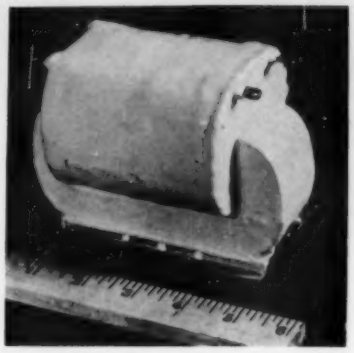
*Trademark

INDUSTRY AND **KENNAMETAL**

...Partners in Progress

For more information, turn to Reader Service card, circle No. 519

What's new IN MATERIALS



***Transformer** encapsulated with silicone-modified resin.*

The resin is recommended for treatment of filaments and power and plate transformers.

Other News . . .

Metals

▸ Haynes Stellite Co., Div. of Union Carbide Corp., 420 Lexington Ave., New York 17, announced recently that it has been licensed to produce International Nickel Co.'s nickel-base alloy Inconel 713-C and Utica Metal's (Div. of Kelsey-Hayes Co.) Udimet 500 alloy. The alloys will be sold under the trademarks, Haynes Alloy No. 713-C and Hastelloy Alloy No. 500.

▸ Improved Stressproof steel bars are being marketed by La Salle Steel Co., 1420 150th St., Hammond, Ind. La Salle says improvements have been made in strength, tolerances and machinability.

▸ Expanded titanium sheet for use in the plating and chemical industries was introduced recently by Mallory-Sharon Metals Corp., Niles, Ohio. The material is available in gages from 0.050 to 0.125 in. in standard 48 x 96-in. sheets.

▸ Iochrome, a high purity chromium (almost 100% pure) is now commercially available from Chromalloy Corp., 450 Tarrytown Rd., White Plains, N. Y. Tests show the material has an elongation of 44% and a reduction in area of 78%. Iochrome is produced by an iodide decomposition process.

(more News on p 178)

ENJAY BUTYL

creates a world of quiet in new Imperials

Enjay Butyl adds to the comfort and enjoyment of new Imperials in two important ways: by sealing out sound *and* weather. Enjay Butyl is ideal for applications involving exposure to sun and weather, for Butyl is highly resistant to heat, sunlight, aging and ozone. Butyl also offers outstanding resistance to chemicals, abrasion, tear and flexing... superior damping properties... unmatched impermeability to gases and moisture. Tough, low-cost Butyl is the right rubber for many varied uses. Find out how this versatile product can improve your product.

For complete information...
write or phone your nearest Enjay office. Enjay's extensive laboratories and expert staff are always glad to provide information and technical assistance.

EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY COMPANY, INC.
15 West 51st Street, New York 19, N. Y.
Akron • Boston • Charlotte • Chicago • Detroit • Los Angeles • New Orleans • Tulsa

ENJAY® BUTYL

For more information, turn to Reader Service card, circle No. 503

makes Fluoroflex®-T pipe permanently corrosion-proof

USING the pipe lining *material* that handles highly corrosive fluids is only half the job. Keeping it *in place*, despite wide temperature fluctuations, is equally important. Fluoroflex-T Type S piping solves both problems . . . assuring unequalled pipe and fitting life.

Lining is universally inert to all corrosives. It's made of Fluoroflex-T, a high density, non-porous compound* of virgin Teflon.

Liner and housing in thermal equilibrium, through an exclusive process developed by Resistoflex. It compensates for thermal expansion differential between the Teflon and housing, eliminating fatigue collapse, and cracking at the flare.

Bulletin TS-1A gives more details. Write Dept. 171, RESISTOFLEX CORPORATION, Roseland, N. J. Other plants: Burbank, Calif.; Dallas, Tex.

* *Pat. No. 2,752,637*

®Fluoroflex is a Resistoflex trademark, reg., U.S. pat. off.
®Teflon is DuPont's trademark for TFE Fluorocarbon resins.

RESISTOFLEX

For more information, turn to Reader Service Card, circle No. 383

What's new IN MATERIALS

Nonmetallics

▸ Four of Escambia Chemical Corp.'s PVC resins are now on the Underwriters' Laboratories interchangeability list for electrical applications. Escambia, located at 261 Madison Ave., New York 16, says the resins have outstanding insulation resistance and good electrical properties.

▸ A fast-curing silicone rubber, identified as Silastic RTV 502, vulcanizes in 30 min at room temperature. The vulcanized rubber retains flexibility from –70 to 500 F, has good electrical insulating properties, and resists weathering, moisture, ozone and corona. It is available from Dow Corning Corp., Midland, Mich.

▸ A synthetic rubber-coated nylon fabric has been developed as a diaphragm material in gas appliance regulators, automobile oil gages and other controls. Designated Buna-N/Nylon Reevecote, the material is reported to be about 100% more heat resistant than conventional synthetic rubber-coated diaphragm fabrics. The material is available from Vulcan Rubber Products Div., Reeves Brothers, Inc., 1071 Avenue of the Americas, New York 18.

Finishes

▸ A new paint for the protection of rusted, weathered and new galvanized surfaces has been announced by Lead Industries Assn., 60 E. 42nd St., New York 17. The paint is made of a red lead–iron oxide–zinc dust pigment in an alkyd resin.

▸ An aluminum-pigmented, silicone-base paint is said to withstand temperatures up to 1700 F. The paint is said to virtually fuse with hot surfaces to form a continuous, uniform and attractive coating. Called Heat-Rem H-170, the paint is available from Speco, Inc., 7308 Associate Ave., Cleveland 9, Ohio.

Joining materials

▸ A filler metal and a fluxing agent for low temperature torch soldering of titanium has been developed by Curtiss-Wright Corp., Research Div., Dept. 120, Quehanna, Pa. Joints of 40,000 psi strength can be made with the fluxing agent and filler metal.

▸ A copper-coated welding wire specially designed to weld AISI 1025 steel to AISI 1045 steel has been introduced by Page Steel & Wire Div., American Chain & Cable Co., Inc., Monessen, Pa. The wire is called Page A-S-18.

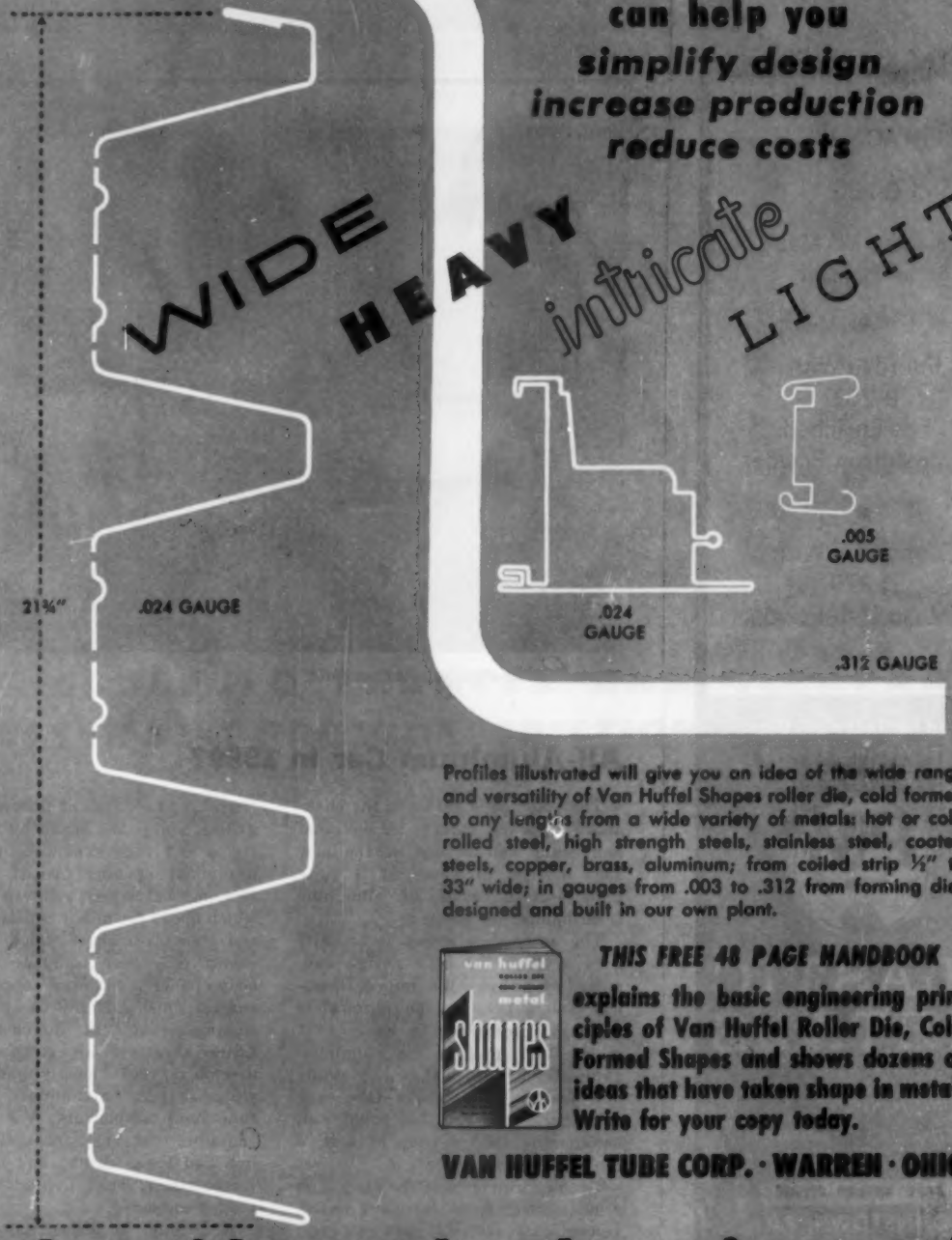
van huffel

ROLLER DIE COLD FORMED

metal shapes

can help you
simplify design
increase production
reduce costs

WIDE HEAVY intricate LIGHT



Profiles illustrated will give you an idea of the wide range and versatility of Van Huffel Shapes roller die, cold formed to any length from a wide variety of metals: hot or cold rolled steel, high strength steels, stainless steel, coated steels, copper, brass, aluminum; from coiled strip ½" to 33" wide; in gauges from .003 to .312 from forming dies designed and built in our own plant.

THIS FREE 48 PAGE HANDBOOK

explains the basic engineering principles of Van Huffel Roller Die, Cold Formed Shapes and shows dozens of ideas that have taken shape in metal. Write for your copy today.

VAN HUFFEL TUBE CORP. · WARREN · OHIO

where ideas take shape in metal

For more information, turn to Reader Service card, circle No. 442

PLAST-IRON POWDERS

REPLACE WITH

B-280

Standard 80 Mesh Iron Powder

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Improve With B-281 Phos Enriched 80 Mesh Iron Powder

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Economize With B-270 35 Mesh Iron Powder

PM 94

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PLASTIC METALS

Division

National-U.S. Radiator Corporation

4459 BRIDGE STREET

JOHNSTOWN, PA.

For more information, circle No. 385

Insulation—
cont'd from p 12

conventional manner.) After winding, the motor is potted with a liquid slurry consisting of phosphate solution, Wollastonite, silica and other chemically reactive materials.

Results of tests indicate that the motor can operate successfully for short periods of time at temperatures up to 1000 F; at 950 F, the motor will successfully operate for several thousand hours.

Other materials used in the motor include: heat treated Ni-Resist iron for the frame and end bells, pure silver wire for windings, and special bearings (material undisclosed).

***Model** of all-aluminum automobile.*

All-Aluminum Car in 1960?

The automobile shown in the photo above appears rather conventional and could well be one of the new 1959 models. However, it is quite unique—it is made of aluminum from bumper to bumper.

The automobile shown is actually a ⅝ scale model of a design submitted by Kaiser Aluminum & Chemical Sales, Inc., to the automobile industry. According to Kaiser, "It is the sum total of the aluminum applications, rather than any single new feature, that makes (the car) an exciting concept that could well become the 1960 version of today's conventional sedan."

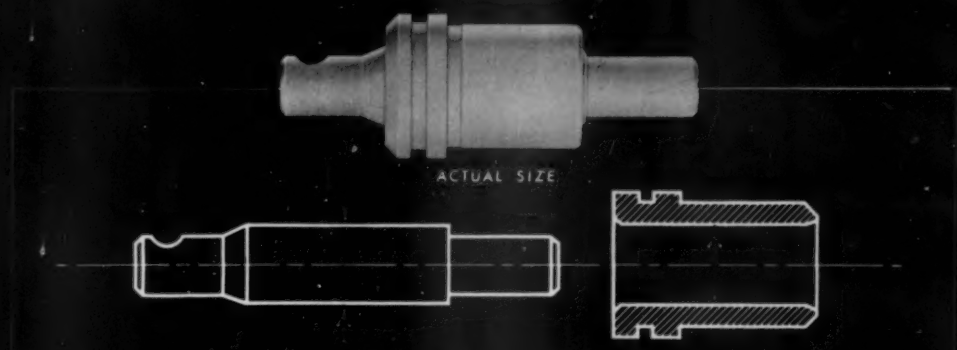
Here's a rundown of the aluminum applications: front bumper: center section extruded, end sections cast; rear bumper: center section extruded, end sections of formed sheet; grille: honeycomb made by bonding strips and then expanding to form hexagonal opening; hood: a two-section, extruded roll-away door which opens for minor repairs; front end structure: sheet which may be raised to expose complete engine; body panels: stamped sheet with enamel finish; doors: two-piece die castings; rear deck: die castings or formed sheet over an extruded frame assembly; roof: mostly glass with wedge-shaped aluminum panels; functional components: V-8 engine; radiator; die cast integral wheel, hub and brake drum; and the auto frame itself: built-up cast and extruded sections.

According to Kaiser, all of the applications take advantage of alu-

For more information, circle No. 471 ➤

Coors CERAMICS

HIGH PRECISION TOLERANCES



SHAFT		BUSHING	
Diameter	±0.000015	Diameter	±0.000020
Taper	0.000010	Taper	0.000010
Camber	0.000010	Camber	0.000010
Out-of-Roundness	0.000010	Out-of-Roundness	0.000010

BENDIX AVIATION CORPORATION SHAFT AND BUSHING ASSEMBLY

VERY CLOSE TOLERANCES AND CLEARANCES ON ASSEMBLY PROVIDE FRICTION FREE ACTION

Coors Alumina Ceramic is used in production quantities by the Bendix Aviation Corporation for a shaft and bushing assembly that has tolerances as close as ±0.000015. From one bushing to another, Coors holds the diameter to ±0.000050. Between one shaft and another, Coors holds the diameter to ±0.000015. On both bushings and shafts, taper, camber and roundness of individual parts are held to 0.000010 total.

Extremely close, match-fit sets of this assembly are made by selective fitting. Finishing within a few millionths is required to provide proper fits—exact clearance must be withheld.

These very close tolerances and clearances provide friction free action between the shaft and bushing. This, combined with the hardness and chemical inertness of the alumina ceramic, gives the assemblies long, trouble free service.

Guaranteed precision on a production basis permits the engineer to use Coors ceramics in applications where the physical properties of metals and plastics are unacceptable. Tolerances and finishes which can be obtained by Coors are:

Diametrical.....within 0.000030" total.
Taper.....0.000010" per inch of length*.
Camber.....0.000010" per inch of length*.
Out-of-roundness.....0.000010".
Surface flatness—less than 1 light band.
Equivalent surface finish—
3 to 4 r.m.s. microinch.

*(in lengths up to 3 inches)

For a complete description of physical properties of Coors High Alumina Ceramics, write for Bulletin 1055A.

COORS PORCELAIN COMPANY

Manufacturers of High Strength Alumina Ceramics
GOLDEN, COLORADO

COORS PORCELAIN CO., 616 9th St., Golden, Colo.
Please send me detailed Bulletin 1055A on Coors High Strength Alumina Ceramics and Coors manufacturing facilities.

Name.....Title.....
Company.....
Address.....
City.....State.....

minum's light weight and high strength, corrosion resistance, workability, attractive appearance, and ability to be finished with a variety of treatments.

Strippable Butyrate Cuts Plating Costs

Cost and time of masking metal parts for partial plating has been substantially reduced as a result of the switch from conventional lacquers to strippable butyrate plastics coating.

Parts to be plated are simply dipped into the molten plastic and allowed to dry for 60 sec. The butyrate coating is then trimmed, or stripped, away from the areas to be plated. After plating, the remaining coating is stripped off, rinsed and returned to the melt tank for reuse.

One partial plating problem that was successfully solved through the use of strippable butyrate is the airplane wing control lever shown in the accompanying photo. Specifications called for the part to be completely cadmium-plated except for six bearing surfaces, which were to be lead-plated.

The problem was solved by plugging the bearing holes with butyrate prior to cadmium plating. Following the cadmium plating, the plugs were removed and the entire part dipped into the molded butyrate. The buty-

Eastman Chemical Products, Inc.
***Butyrate coating** is easily stripped off after partial plating.*

A—Refrigerant receiver—6″ x 48″
B—Air die cushion receiver—8″ x 20″
C—Air brake and air clutch receiver—10″ x 30″
D—Dental compressor receiver—16″ x 13″

Hackney air receivers...made to your specifications for any service

Whatever your special requirements or standard applications, your Hackney air receivers will meet all code requirements. And they'll be made two-piece, with *one* weld uniting the deep drawn sections into a strong, lightweight receiver.

Standard Hackney air receivers, horizontal model, are available in capacities of 30, 60, 80 and 120 gallons; vertical models, in 60- and 80-gallon sizes. Specially designed receivers for refrigerants or compressed air vary in capacity with their specifications.

For complete information on Hackney air receivers, write today.

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1442 South 66th Street, Milwaukee 14, Wisconsin
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CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

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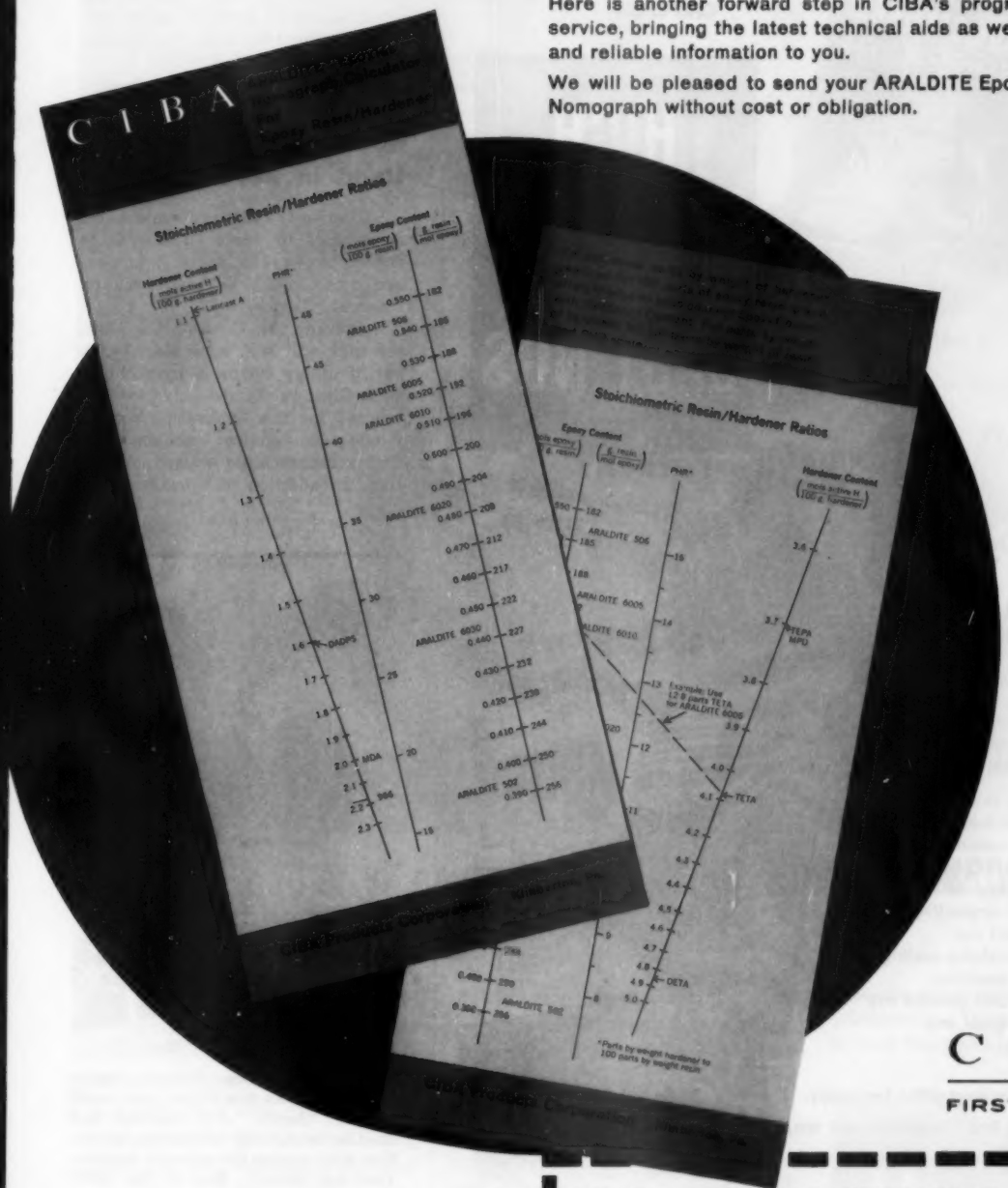
Another CIBA Service...

The ARALDITE® Epoxy Resin/Hardener Nomograph ... A Handy New Idea For Determining Hardener Quantities

Handy... Simple... Accurate... this unique aid will enable you to determine epoxy resin/hardener ratios instantly. Developed, designed and tested by CIBA, the ARALDITE Epoxy Resin/Hardener Nomograph* is already proving its value in day-to-day formulating with epoxies.

Here is another forward step in CIBA's progressive program of service, bringing the latest technical aids as well as new products and reliable information to you.

We will be pleased to send your ARALDITE Epoxy Resin/Hardener Nomograph without cost or obligation.



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Please send without obligation the new ARALDITE Epoxy Resin/Hardener Nomograph.

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COMPANY_____ TITLE_____

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CITY_____ STATE_____

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*Copyright applied for.

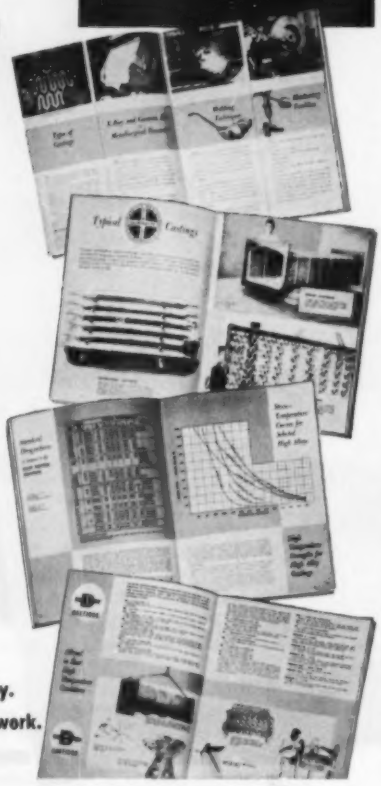
16 pages of useful information about

HIGH ALLOY CASTINGS

DURALOY DURASPUN

This is our New General Bulletin—3354G. It's full of information and data on the chrome-iron and chrome-nickel castings so necessary when corrosion, high temperatures and abrasion must be resisted. It will serve as a general selection guide for those specifying or using such castings.

The bulletin also reviews briefly our experience in both static and centrifugal castings, an experience going back to the pioneering days of 1922 and 1933 respectively. It also tells about our facilities for furnishing castings to any desired analysis, welding, X-ray and gamma ray testing, metallurgical and foundry control.



WRITE or CALL our nearest office for a copy.

We believe you will find it helpful in your work.

The DURALOY Company

OFFICE AND PLANT: Scottdale, Pa.

EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.
ATLANTA OFFICE: 76—4th Street, N.W.
CHICAGO OFFICE: 332 South Michigan Avenue
DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.

For more information, turn to Reader Service card, circle No. 463

rate which penetrated the bearing holes was then trimmed away and the part immersed in the lead plating bath.

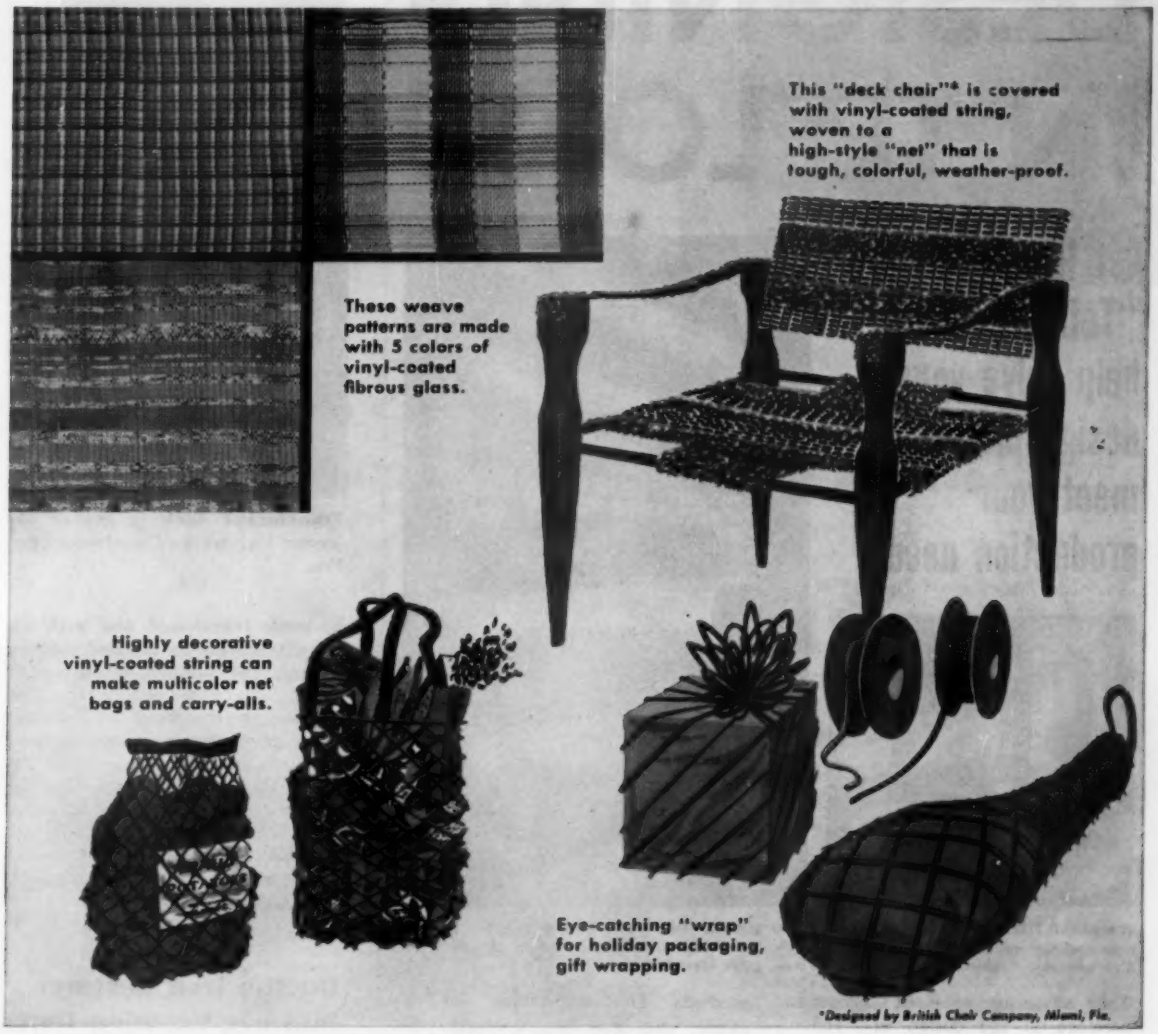
Reinforced Plastics Used in Acid Tank

Shown in the accompanying photo is one-half of what is said to be one of the world's largest acid storage tanks ever fabricated from reinforced plastics.

According to Ceilcote Co., Inc., the tank will hold more than 14,000 gal of highly corrosive hydrochloric acid. Glass-reinforced polyester was selected for this application because it offers an excellent combination of high strength, light weight and low cost. In addition, the material can

Heated drive-ins—Drive-in movie enthusiasts can now enjoy year-round comfort thanks to a heating unit said to be capable of heating an entire auto even in the severest weather (see top photo). Key to the unit's efficient operation is an aluminum die casting which acts as the heating element (see lower photo). According to Ainsworth-Precision Castings Co., aluminum was selected because its good heat conductivity and ability to be cast with thin fins provide good distribution of heat.

A NEW WAY TO UPGRADE YOUR PRODUCTS: VINYL COATINGS


These weave patterns are made with 5 colors of vinyl-coated fibrous glass.
This "deck chair"* is covered with vinyl-coated string, woven to a high-style "net" that is tough, colorful, weather-proof.
Highly decorative vinyl-coated string can make multicolor net bags and carry-alls.
Eye-catching "wrap" for holiday packaging, gift wrapping.
*Designed by British Chair Company, Miami, Fla.

Colorful, "leather-y" coatings for STRING, ROPE or FIBROUS GLASS

You can put a smooth, tough coating of vinyl on rope, string, thread, or filaments of fibrous glass with a continuous dip and cure process using a vinyl dispersion. The coatings transform these basic materials into something new, different, colorful with wider marketing potential.

Tough vinyl "skin" up to 1/16" (60 mils) thick can be applied by a single dipping. Color range is unlimited, and the toughness and flexibility can be controlled by the formulation of the dispersion. For sources of vinyl-coated string, rope or glass filaments—or for sources of ready-to-use dispersions for coating sheet metal, wire, expanded steel, or glass, write Monsanto.

Monsanto manufactures a wide variety of plasticizers and Opalon® resins for formulators of these high-quality vinyl dispersions.

Organic Chemicals Division
MONSANTO CHEMICAL COMPANY
Dept. SP-5, St. Louis 66, Missouri

Monsanto®

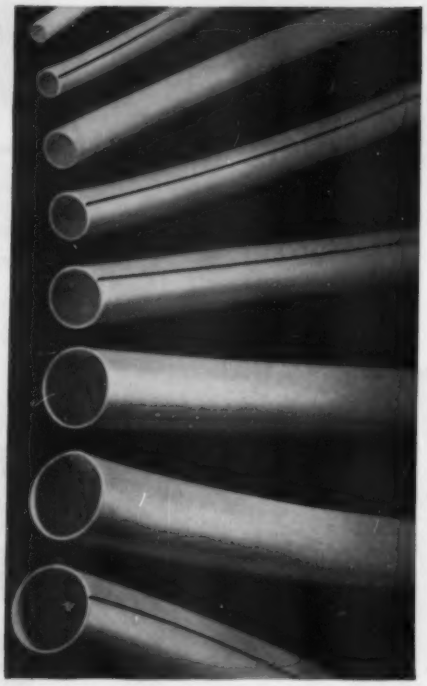
Where Creative Chemistry Works Wonders for You

For more information, turn to Reader Service card, circle No. 431

DESIGNING IN TEFLON*?

Let R/M's complete "Teflon" service help solve your design problems... meet your production needs

STANDARD FORMS. Tubes, rods, sheets, tape and thin-wall tubing are available. Also bondable "Teflon."



NEW STRIPED THIN-WALL TUBING can be supplied with identifying stripes in a variety of colors, for sure, quick identification.

Take advantage of R/M's broad experience in the design of "Teflon" parts and ample facilities for its fabrication. R/M sales engineers have cut costs for customers by suggesting a minor change in design—without affecting performance—or a more efficient method of fabrication. Where a standard form will do the job, R/M offers a vast array of "Teflon" sheets, rods, tubes, thin-wall tubing and tape . . . standard or bondable.

And R/M is constantly working to develop new varieties of "Teflon" products. Thin-wall tubing, for example, can now be furnished with permanent color striping for identification purposes. And 1/32-in.-thick "Teflon" can now be supplied in sheets 36 x 36 in. . . . greater thicknesses in 48 x 48 sheets. If you are designing in "Teflon," or considering its use, it will pay you to learn more about R/M's complete "Teflon" service. Contact your nearest R/M district office or write Plastics Products Division, Manheim, Pa.

*A Du Pont trademark

R/M

RAYBESTOS-MANHATTAN, INC.

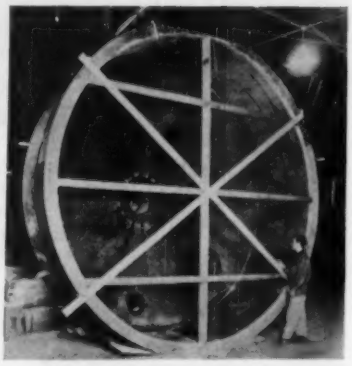
PLASTIC PRODUCTS DIVISION FACTORIES: MANHEIM, PA.; PARAMOUNT, CALIF.

Contact your nearest R/M district office listed below for more information or write to Plastic Products Division, Raybestos-Manhattan, Inc., Manheim, Pa.

BIRMINGHAM 1 • CHICAGO 31 • CLEVELAND 16 • DALLAS 26 • DENVER 16 • DETROIT 2 • HOUSTON 1
LOS ANGELES 58 • MINNEAPOLIS 16 • NEW ORLEANS 17 • PASSAIC • PHILADELPHIA 3
PITTSBURGH 22 • SAN FRANCISCO 5 • SEATTLE 4 • PETERBOROUGH, ONTARIO, CANADA

RAYBESTOS-MANHATTAN, INC., Engineered Plastics • Asbestos Textiles • Mechanical Packings • Industrial Rubber
Sintered Metal Products • Rubber Covered Equipment • Abrasive and Diamond Wheels • Brake Linings
Brake Blocks • Clutch Facings • Laundry Pads and Covers • Industrial Adhesives • Bowling Balls

For more information, turn to Reader Service card, circle No. 469



***Translucent tank** is one of the largest ever made of reinforced plastics.*

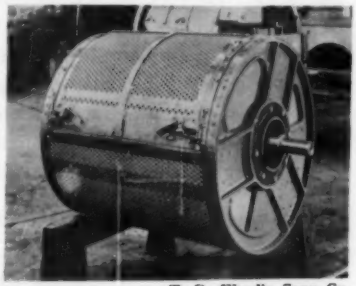
be made translucent and with the installation of an interior lighting fixture, the solution level can be readily determined at any time, thus eliminating the need for external glass gages normally used on such tanks.

The two sections of the tank are bonded together and installed at the site. When erected, the tank will have a 14-ft dia and an overall height of 14 ft. No external supports are necessary.

Ductile Iron Castings Improve Washing Unit

Use of ductile iron castings in place of malleable iron castings has solved a number of problems in the design of cylinder heads for laundry washers.

According to W. H. Nicholson & Co., the previously used malleable



T. B. Wood's Sons Co.

***Cylinder heads** of washing machine are made of ductile iron castings.*

These workmen are using Youngstown Yoloy "E" high-strength steel to fabricate belt rails—a component of DF Loaders—at Evans Products Co.

Accent on Excellence

Youngstown Yoloy "E" high-strength steel

Two DF* Loader-equipped railroad cars easily do the work of three standard box cars. That's because DF cars (31,000 now in service) can be loaded to capacity—earn greater revenue for railroads.

Portions of Evans DF Loaders are fabricated from Youngstown's Yoloy "E" Angles and Hot-Rolled Yoloy Sheets by Evans Products Company, Plymouth, Michigan. All Yoloy Steels are produced to meet a wide range of applications, where high strength and corrosion-resistance are of prime importance.

Wherever high strength steel becomes a part of things *you* make, the high standards of Youngstown *quality*, the personal touch in Youngstown *service* will help you create products with an "accent on excellence".

**DF is a trademark of Evans Products Company.*

EVANS DF LOADER *. . . Locks in lading, eliminates damage and dunnage*

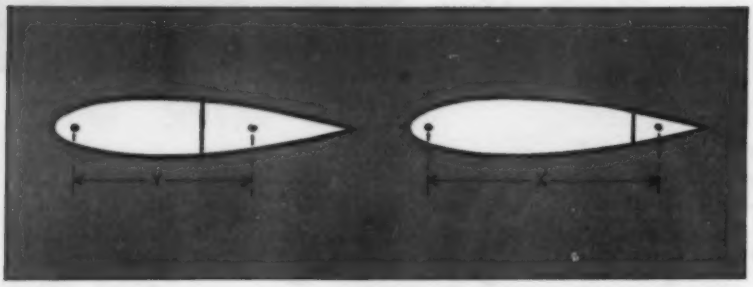
Send for free technical bulletin on Youngstown Yoloy "E" Steel.

THE **YOUNGSTOWN** SHEET AND TUBE COMPANY

Manufacturers of Carbon, Alloy and Yoloy Steel, Youngstown, Ohio

For more information, turn to Reader Service card, circle No. 432

A Heavier Metal to Save Weight?



Compare aileron counterweight design with (left) conventional material and (right) with Mallory 1000.

A smaller quantity of high-density Mallory 1000 can achieve just that . . . by providing the required mass for balancing or inertial energy in a smaller space, thus reducing the size of related structural members, housings and actuating devices.

Mallory 1000 properties—high density, high strength, machinability, high modulus—permit strategic counterweight location for maximum balancing or inertial effect with less weight . . . a net saving in the total weight of the device.

Mallory 1000 is a machinable alloy weighing 16.96 grams per cubic centimeter. Mallory 1000 micro-structure is uniform and homogeneous. Mallory 1000 also provides up to 40% greater radioactive shielding efficiency than lead, making it a superior material for radiation-source containers.

What new and unusual applications for more weight in less space are on your drawing boards? Complete data or consultation available on request.

Density	16.96 grams/cc Average
Ultimate tensile strength	112,000 psi. Average
Modulus of Rupture (simple beam, center loaded)	220,000 psi. Average
Elongation (percent in 2")	2.5% Minimum
Hardness Rockwell "C"	24-30
Modulus of Elasticity	40,000,000 psi.
Coefficient of Expansion 25-500°C	5.4 x 10^6 in./in./°C
Electrical Conductivity	14.0% IACS
Proportional Elastic Limit (in tension)	25,000 psi.
Yield Strength (0.2% offset)	75,000 psi.
Torsion Modulus (modulus of rigidity)	19,200,000 psi.
Angle of Twist at Rupture	166°
Shear Strength	81,000 psi.

P. R. MALLORY & CO. Inc.
MALLORY
P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

For more information, turn to Reader Service card, circle No. 411

MATERIALS AT WORK

iron castings (36 or 42 in. in dia and 2 in. thick) had three shortcomings: 1) a tendency to warp or crack during annealing; 2) a delivery time of three or four weeks after casting because of the long, slow annealing necessary to create the malleable structure; and 3) a tendency to crack during machining because of "locked-up" internal stresses.

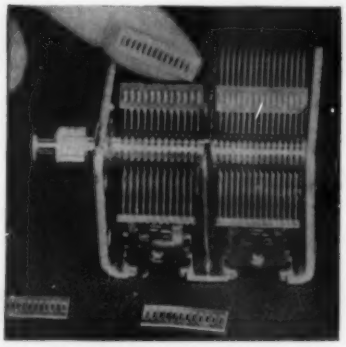
With ductile iron castings these problems are eliminated; no annealing is necessary and machinability is said to be equal to or better than that of steel. In addition, the new castings are said to be tough, rigid and shock resistant.

Precision Insulators Made from Laminate

A linen-base phenolic laminate has solved a close tolerance fabricating problem in the design of intricate electrical insulating spacers used in variable air capacitors. Ten or more rectangular holes 0.018 in. wide and 0.106 in. long had to be punched 0.058 in. apart on a strip of insulating material measuring 025 in. wide, 0.620 in. long and 0.027 in. thick (see photo). In addition, specifications called for extremely high strength, moisture resistance and dimensional stability; tolerances as low as +0.001 —0.000 in.; and excellent punching qualities.

According to National Vulcanized Fibre Co., Phenolite grade Le-606 satisfied all requirements.

(more Materials at Work on p 190)

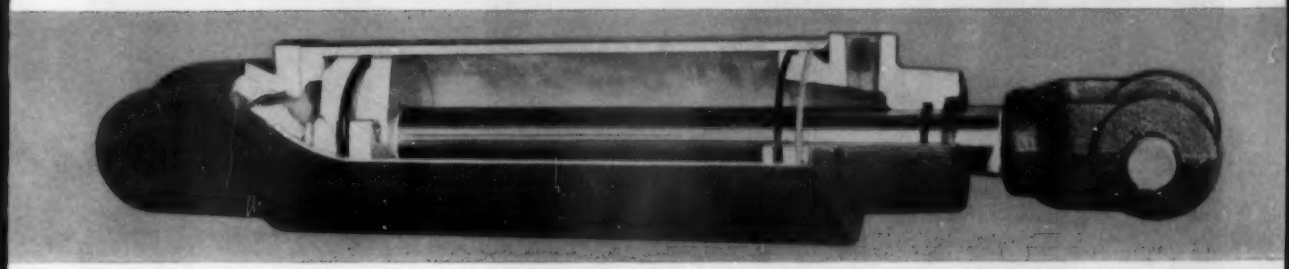


***Tiny insulating spacers** are made of phenolic laminate.*

There's a HOLE lot of sense in this use of mechanical tubing

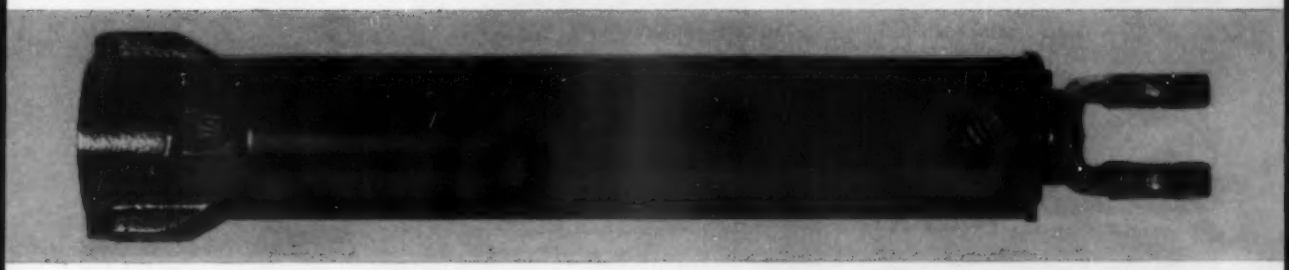
What we're talking about is USS Shelby Seamless Mechanical Tubing. Here's how Industrial Hydraulics Division, Cessna Aircraft Company uses it to boost life, simplify manufacture and lower costs in the hydraulic cylinders they supply to agricultural equipment builders. We quote from their letter to us:

"The cut-away cylinder is a unit we furnish to one of our many customers. This is a 3½" diameter, double-action cylinder used for mounting on pull-behind tools



such as plows, cultivators, and disc harrows. This cylinder uses your Shelby Seamless Mechanical Tubing with the I.D. bored to size and roller burnished to a finish of approximately six to eight RMS. The expected life of this cylinder is in excess of 300,000 cycles, operating at 1,500 psi hydraulic pressure.

"The other cylinder is furnished to another one of our customers, and is a 3¼" I.D. double-action cylinder with a 13" stroke. Used to raise and lower the platform of their self-propelled combine, it is similar to the cut-away cylinder



with respect to finish requirements and material for the barrel. The operating pressure is approximately the same and so is the expected service life of five years, or 300,000 cycles. Generally these cylinders may be serviced for additional use by merely replacing the seals.

"The severe field conditions these cylinders are subjected to are some of the most extreme to which cylinders could be exposed."

In critical mechanical applications like these, and in an almost endless number of fabrications that are essentially tubular in character, Shelby Seamless will ensure improved performance, finer appearance and economical production.

For Shelby Seamless offers more than just a pre-bored hole. It not only combines to an exceptional degree the qualities of strength, uniformity and dimensional accuracy but, in addition, is readily workable and has excellent machining properties. If you want to find out how it can be most effectively applied to your designs, contact your nearby Shelby Distributor.

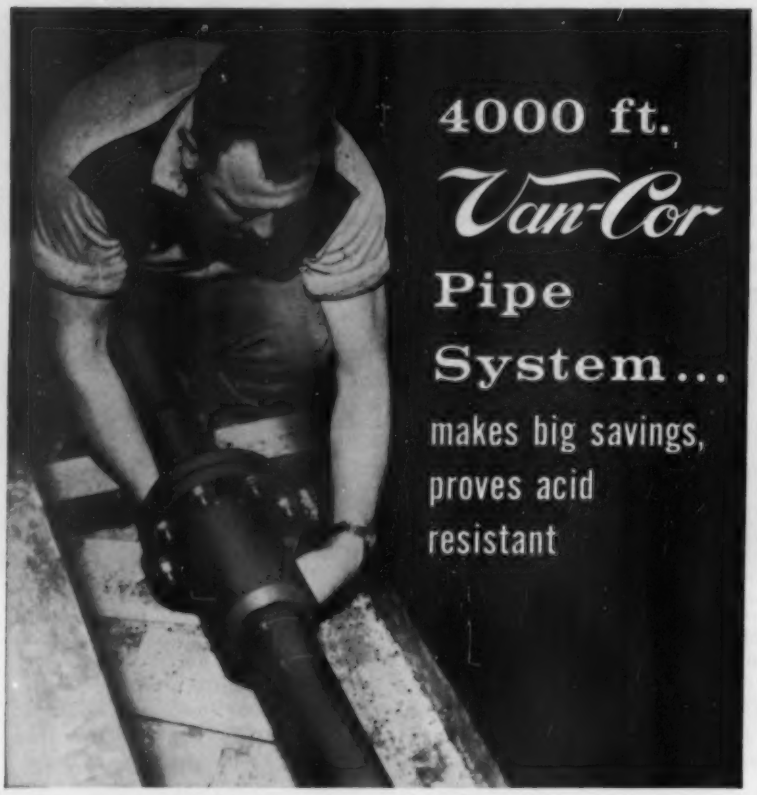
And remember—USS Shelby Tubing is made by the world's largest and most experienced manufacturer of tubular products.

USS and Shelby are registered trademarks

National Tube Division of USS **United States Steel**

For more information, circle No. 493

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors
United States Steel Supply Division • United States Steel Export Company, New York



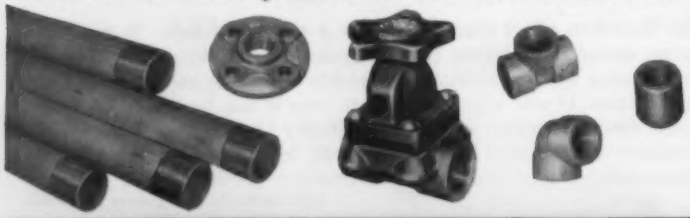
At the Allentown (Pa.) Works of the Western Electric Co., the entire waste acid disposal system in the recent addition consists of Van-Cor rigid PVC pipe and fittings.

HOW COSTS WERE CUT. Initial price of Van-Cor was ⅓ that of comparable cast iron alloy pipe. On a 6" line, labor costs were estimated at 29¢ per foot of run—about half that of metallic pipe. Also, because Van-Cor has only 1/10 the weight, no mechanized handling equipment was needed. Available in 10 or 20 ft. lengths, Van-Cor requires fewer joints, and eliminates the breakage problem.

CORROSION LICKED. Van-Cor pipe was used because "corrosion resistant" cast metallic pipe had performed short of expectations in an adjacent building. After 1½ years service, the Van-Cor system is in excellent shape, unaffected by such acids as hydrofluoric, hydrochloric, sulphuric, nitric and many plating solutions.

Investigate Van-Cor Pipe, Fittings, Valves, Electrical Conduit, and Fabrications . . .

Write for Catalog and Name of Nearest Distributor



INDUSTRIAL DIVISION OF . . .

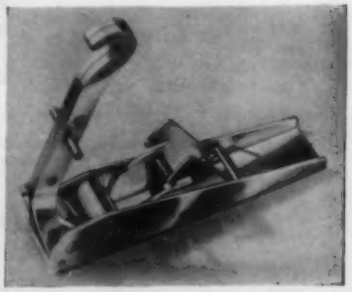
COLONIAL PLASTICS MFG. CO.

Subsidiary of THE VAN DORN IRON WORKS CO.

2685 EAST 79TH STREET CLEVELAND 4, OHIO

For more information, turn to Reader Service card, circle No. 453

MATERIALS AT WORK



***Light weight latch** uses beryllium copper to meet rigid requirements.*

Beryllium Copper Latch Meets Aircraft Specs

Specifications for a new aircraft flush latch called for the unit to be completely nonmagnetic, lightweight, corrosion resistant, identical in size with existing stainless steel latches, and capable of withstanding a 1000-lb static tensile load. Beryllium copper was selected because aluminum and other light metals would have been too bulky to meet the strength requirement.

According to Beryllium Corp., not only did the beryllium copper satisfy all requirements, but was actually found to withstand up to 1230 psi before bending. Moreover, the latches could be run on the same punch die used to make the stainless steel latches. The only problem encountered was a tendency on the part of the cold rolled metal to crack during forming of the extremely sharp radii required for a flush fit with aircraft skins. The problem was easily solved by using annealed strip.

One other precaution was taken: in order to avoid the possibility of galvanic action between dissimilar metals, the flush latches are plated with about 0.0003-0.0005 in. of cadmium.

Kel-F Replaces Metal in Potentiometer Parts

The use of molded Kel-F fluorocarbon plastics parts and about 2 ft of Kel-F insulated wire has resulted

CLEAN, SMOOTH-FITTING THREADS

EASY-TO-GRIP HEADS

STRONG, STRAIGHT SHANKS

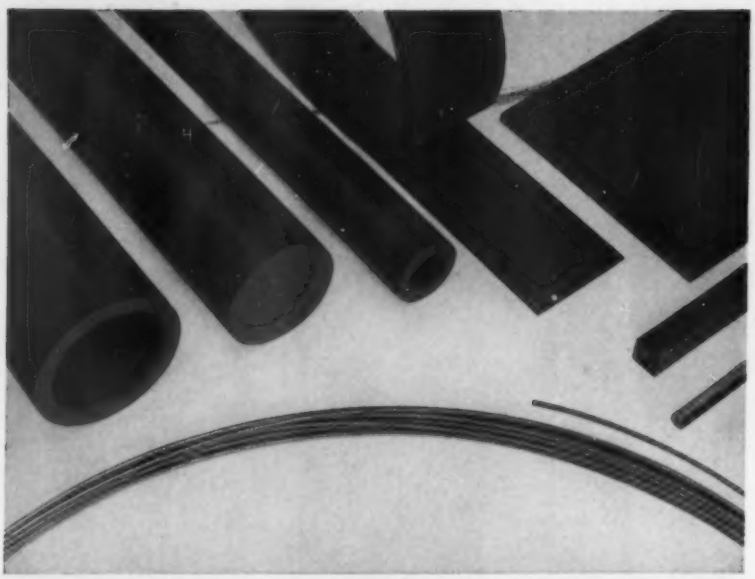
FULL RANGE OF STYLES AND SIZES

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA. On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

For more information, turn to Reader Service card, circle No. 407



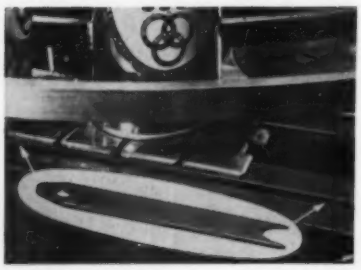
NYLATRON® G S

Gives the property advantages of nylon, PLUS... improved mechanical characteristics:

- Greater Rigidity—higher modulus of elasticity, less deformation under load.
- Higher Heat Distortion Temperatures—distortion temperatures 70% higher than nylon 101.
- Lower Thermal Expansion—coefficient approximately 60% of nylon 101.
- Low Surface Friction—can be used without lubrication.
- High Wear and Abrasion Resistance—can outlast, outperform metal.

NYLATRON GS, a molybdenum disulphide filled nylon*, is formulated to expand the field for nylon parts such as bearings, bushings, liners or other wear parts. Its superior mechanical and thermal characteristics coupled with the chemical and electrical properties of nylon result in a material with proven advantages. It is produced under controlled manufacturing standards to assure the ultimate in uniformity, quality and reliability.

Stock shapes of NYLATRON GS include rod, strip, tubing, tubular bar and plate in all standard sizes—for rapid, low-cost fabrication on standard metalworking tools. In addition, it is available in powder form for molding.



NYLATRON GS wear strips provide excellent wear cushion between metal bottling chain and conveyor stands. Due to inherent wear resistance and low surface friction, NYLATRON outwears metal strip while reducing wear on chain and stand.

Polymer can also supply stock shapes of all commercial nylons on request.

Write today for detailed information about NYLATRON GS—or other nylon formulations to meet your specific requirements.

*Patents applied for

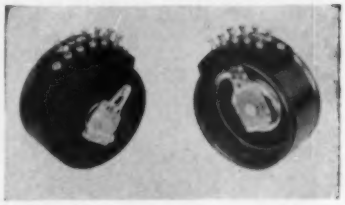
THE POLYMER CORPORATION OF PENNA.
Reading, Pennsylvania
Export: POLYPENCO, INC., Reading, Pa., U.S.A.

POLYPENCO

POLYPENCO Nylon, POLYPENCO Teflon†, NYLAFLOW® and NYLATRON® GS †DU PONT TRADEMARK

For more information, turn to Reader Service card, circle No. 507

MATERIALS AT WORK



***Kel-F clamp** (left) and wiper (right) reduce cost of potentiometer.*

in a cost saving of over 50% in the manufacture of precision potentiometers.

According to Minnesota Mining & Mfg. Co., the major cost advantage was achieved as a result of the switch from metal to Kel-F for the clamps and "wipers," thus eliminating the silver or cadmium plating previously required. In addition, phenolic insulators, normally used to insulate metal parts from the shaft, are no longer necessary.

Glass-Phenolic Clutch for Better Holding

Glass-reinforced phenolic has replaced metal for the clutch cones used in automatic transmissions.

According to Baker Bros., Inc., the increased torque of today's automobile engines necessitated an increase in the holding power of the clutch cones (which function as a brake to stop a steel ring gear while the transmission is under power). Two solutions were open to the designer: increase the applied pressure or turn to a new clutch material.

Glass-reinforced phenolic was selected because it is lighter than previously used metal and because it can withstand heat, severe static and dynamic friction, the 5000-lb applied force, and the effects of transmission oil.

***Clutch cones** have 6½-in. o.d. and an angle tolerance of ±11 min.*

MEL-TROL® gives you **design insurance** on high temperature parts like this

You design for consistent performance. Production demands consistent fabrication properties. You have to have both. If high temperature alloys don't give you both, you'll often find that the cause is lack of uniformity. And you can usually trace it right back to the original ingot your alloy came from.

MEL-TROL stops this kind of trouble before it can start. The newest and most accurate quality controls guard MEL-TROL alloys throughout the steelmaking process. Steel is poured into the new, *Carpenter*-patented ingot mold that produces greater uniformity in the ingot than is possible by conventional steelmaking processes.

The result is more consistent fabrication behavior and better finished parts. MEL-TROL also pays dividends in high temperature performance over and above conventional steels. Insure the producibility and performance of your high temperature designs with MEL-TROL alloys. Call *Carpenter* for the alloy you need, today.

Carpenter STEEL

The Carpenter Steel Company, Main Office and Mills, Reading, Pa.
Alloy Tube Division, Union, N. J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.
Webb Wire Division, New Brunswick, N. J.

For more information, turn to Reader Service card, circle No. 450

NATIONAL...AN OUTSTANDING SOURCE FOR BASIC MATERIALS

Over 100 grades — Fabricating Specialists — Technical Services — Stock Plan

SHEETS • RODS • TUBES • ROLLS • COILS • FABRICATED PARTS

NATIONAL VULCANIZED FIBRE

Tough
Light-weight
Wear Resistant
Good Dielectric Strength
Impact Resistant
Arc Resistant
Heat Resistant
Track Resistant
Durable
Machinable

Among engineering materials Vulcanized Fibre is outstanding in its application versatility. One of industry's toughest materials, it weighs less than half as much as aluminum. It is easily formed, deep drawn, machined, polished, painted, embossed, or combined with other materials.

EASILY FABRICATED

ARC RESISTANT

FLAME RETARDANT

LIGHT — DURABLE

A thermoplastic material with excellent mechanical properties. A good electrical insulator, it is characterized by its toughness, durability and low coefficient of friction. Available as extruded strip, rod, tubing, special shapes or fabricated parts, National Nylon possesses . . .

NATIONAL nylon

Wear Resistance
Resiliency
Mechanical Strength
Machinability
Low coefficient of friction
Good electrical properties
Impact Resistance

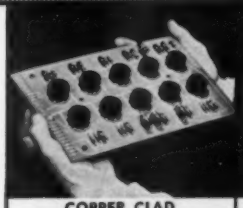
PHENOLITE laminated PLASTIC

Dielectric Strength
Structural Strength
Dimensional Stability
Machinability
Heat Resistance
Moisture Resistance
Chemical Resistance
Wear Resistance
Flame Resistance

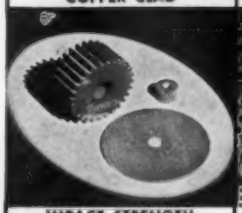
A plastic laminated into primary forms—sheets, rods, tubes under heat and high pressure.

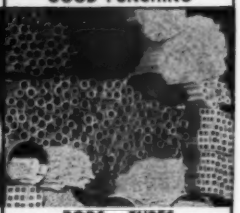
A wide variety of base materials—paper, canvas, cotton fabric, asbestos, glass cloth, glass mat, and nylon cloth—are impregnated with resin binders—phenolic, silicone, polyester, melamine, and epoxy—providing a broad range of grades with an unlimited application base.

Available as copper clad and in combination with vulcanized fibre, rubber and other materials.


COPPER CLAD

GOOD PUNCHING


IMPACT STRENGTH


RODS — TUBES

Write for these illustrated catalogs • Basic Materials Catalog • Fabricated Parts Booklet • Copper Clad Phenolite Brochure • National Nylon Brochure

NATIONAL VULCANIZED FIBRE CO.

Department X-2, Wilmington 99, Delaware

For more information, turn to Reader Service Card, circle No. 484

PRICES AND SUPPLY

...AT A GLANCE

Price of high density polyethylene has been reduced 5¢ per lb by at least four major producers —W. R. Grace & Co., Phillips Chemical Co., Koppers Co. and Union Carbide Plastics Co., Div. of Union Carbide Corp. The new price, 38¢ per lb for truckload quantities, is only 3¢ per lb above the price of conventional, or low density, polyethylene. Trade authorities feel that the reductions may have three effects: 1) enable high density polyethylene to invade more markets now almost exclusively using conventional polyethylene; 2) force producers of conventional polyethylene to lower their prices; and 3) force polypropylene producers to trim their prices.

Nickel production capacity will be increased in 1959 despite the fact that consumption was almost one million pounds lower this past year than in 1957. Free world producing capacity is now estimated to be 525 million pounds and is expected to increase to 550 million in 1959, 600 million in 1960 and 650 million in 1961.

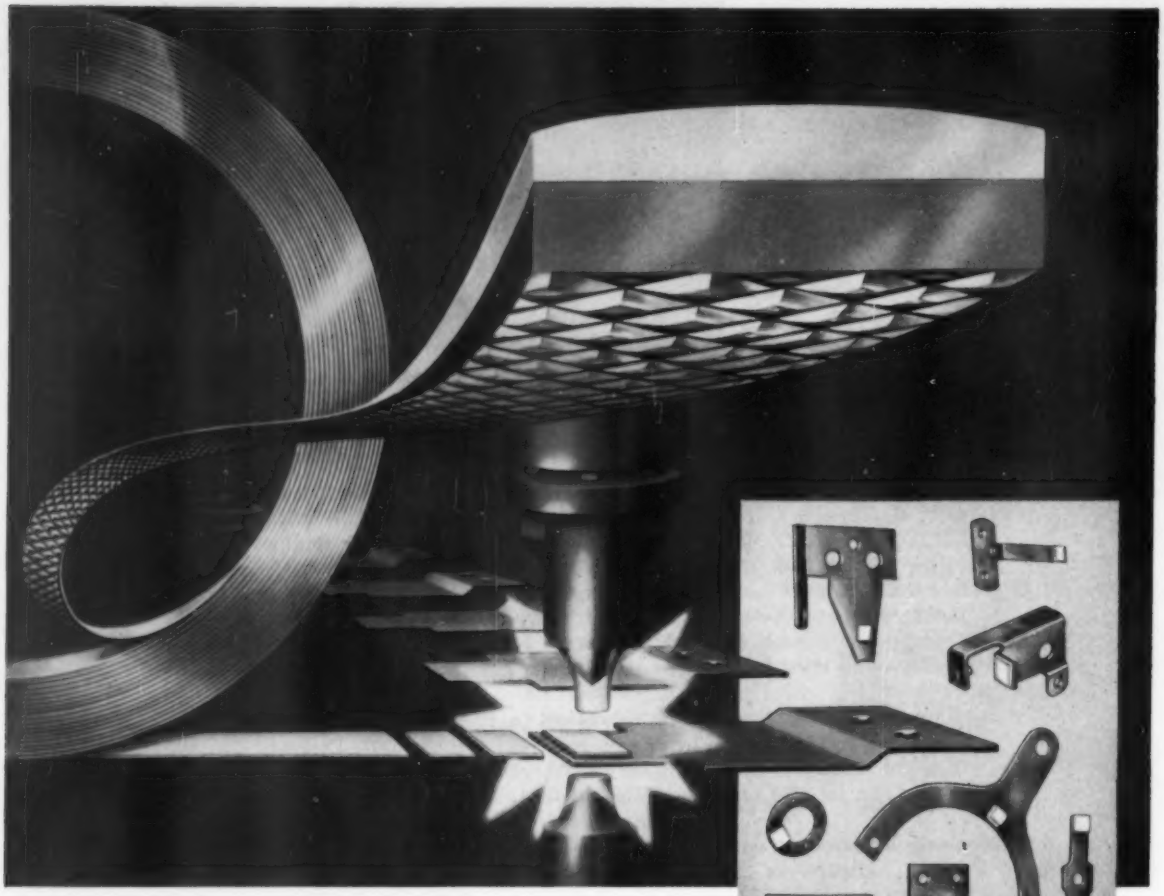
Teflon prices have been cut 8-10% by Du Pont: granular molding powder was cut 40¢ per lb, aqueous dispersions 45¢ per lb and extrusion powder 80¢ per lb. New prices are: Teflon 1, $4.10 per lb; Teflon 5, $4.35; Teflon 6, $6.65; Teflon 7, $4.60; and Teflon 30, $5.15. Reason given for the reduction: "A major breakthrough in manufacturing technique." During the past 15 years, Du Pont has cut Teflon prices a total of 75%.

Three of the major steel producers in this country have agreed that 1959 will see a substantial increase in steel production. The presidents of U. S. Steel Corp., Alan Wood Steel Co. and Inland Steel Co. have, on different occasions, expressed the belief that the industry will operate at about 75-80% of capacity, for a total production of 110-116 million tons. Operation at this level would bring the 1959 production within one million tons of the record set in 1955.

Paper and paperboard production this year will climb to a new high of 32 million tons, according to the Commerce Dept. Output at this rate would be 4% above 1958 production and 2% above the previous record set in 1956.

Consumption and production of natural and synthetic rubber will increase in 1959, according to J. W. Keener, president of B. F. Goodrich Co. The United States will probably use about 1.5 million long tons this year, as compared to 1.3 million in 1958. World consumption of rubber may set a record at about 3.3 million tons. U. S. production of synthetic rubber will increase to about 1.7 million long tons.

Plastics industry has grown too much too soon, according to G. L. Pitzer, vice president for production, Bakelite Co. It seems that the spectacular increases in production have finally run ahead of consumption. Mr. Pitzer cites these examples: consumption of polyethylene in 1958 is expected to exceed 750 million pounds, but capacity is about 1.3 billion pounds; vinyl resin consumption should run about 730 million pounds, but capacity is about 930 million; and styrene consumption will be about 625 million pounds, but capacity is about 850 million.



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Tape contacts are easily attached by spot welding methods. They are self-aligning . . . allow broader assembly tolerances. Because of this, tape contacts reduce assembly costs and eliminate or reduce adjustment time.

Tape contact material is supplied in long continuous lengths which simplify material handling.

In addition to supplying clad electrical contact tape material, General Plate is equipped to weld contact tape sub-assemblies for you.

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New Technical Society

The Society of Aircraft Materials and Process Engineers (SAMPE) is the name of a new technical society recently established on the East Coast to complement two similar groups existing on the West Coast and in the Southwest.

The Society will be concerned with problems of aircraft and missile materials and processes. Membership includes engineering personnel of the aircraft and missile industries as well as of companies either directly or indirectly serving these industries. The Society plans to hold quarterly technical meetings.

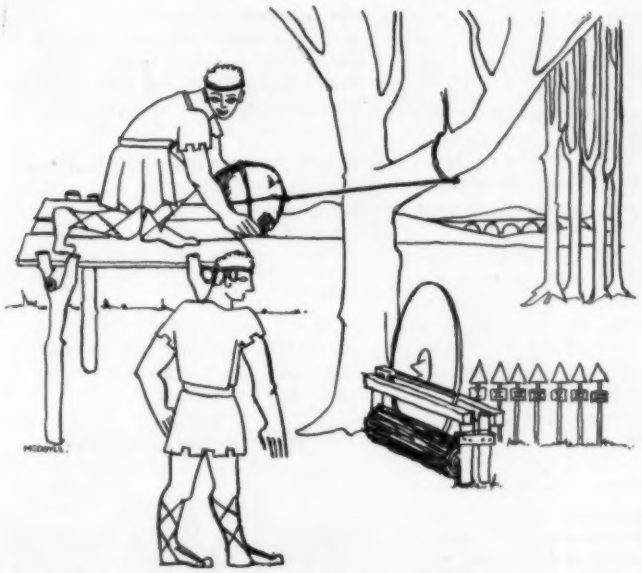
Labs Study Metals, Plastics

Three new research centers for engineering materials, processes and components have been set up:

▸ Research on metals and nuclear fuels will be conducted by Olin Mathieson Chemical Corp. in a new $4-million research center to be completed within the next few months. According to Olin, the metals section will be equipped to perform research in: process metallurgy, fusion welding, corrosion, finishing, bonding, physics, analytical chemistry, physical testing, metallography and engineering development. The nuclear fuel section will be set up to handle: fuel element fabrication, fuel alloys, nuclear materials, ceramics, powder metallurgy, extractive metallurgy, and fuel element reprocessing.

▸ A plastics wing will be added to Enjay Co., Inc.'s research laboratories at Linden, N. J. According to A. Bruce Boehm, executive vice president, the new wing will be essentially a plastics products fabrication plant in miniature and will be used to assist customers with product development and product application problems. Facilities in the new section include injection molding machines, extruders, forming equipment, and laboratories for mixing and compounding, chemical analysis, and physical testing.

▸ An investigation of the problems of flight at speeds up to ten times the speed of sound and altitudes up to 500,000 ft will be conducted in Lockheed Aircraft Corp.'s new research center. In addition to studying various controlling mechanisms, electronic systems, etc., the center will examine and pre-flight test new metallic, ceramic and chemical components for aircraft.



"Izodus thinks a notch will give us better correlation."

Stainless Castings Used Despite Specs

Despite considerable confusion and disagreement on specifications for nuclear power equipment, use of stainless steel castings continues to increase, says the Alloy Casting Institute. The difficulties appear to result from the multiplicity of specifications set by the military services, prime contractors and various standards organizations.

According to the Institute, the main problem seems to be that certain specifications applied to high

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News OF INDUSTRY

alloy castings actually should be applied only to machined surfaces, e.g., the rms surface finish. At the recent Heat & Corrosion Resistant Alloy Castings Conference, held at International Nickel Co.'s Harbor Island Test Station, it was felt that surfaces only half as smooth as those being asked for would be quite adequate.

According to the Institute, high alloy castings are preferred for pumps, valves and fittings used in nuclear power plants for two reasons: 1) the complex shape of this type of equipment is most economically made by casting, rather than by welding, forging, etc., and 2) at temperatures above 1500 F, cast alloys have higher strength than "comparable" wrought alloys. As a result, the high alloy castings are finding increased usage in spite of the specifications which would normally rule them out.

Gray Iron, Epoxy Tools Subjects of Seminars

Two separate series of one-day meetings covering epoxy tooling materials and gray iron castings have been scheduled for 1959 by Ren Plastics, Inc. and the Gray Iron Founders' Society.

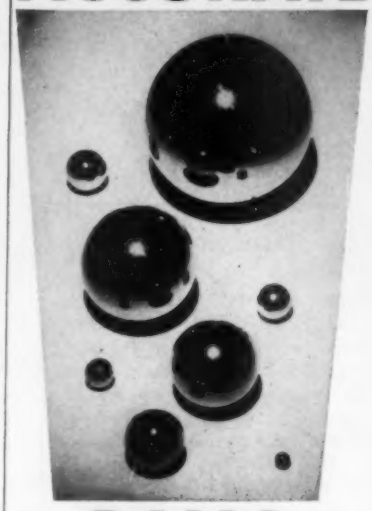
Gray Iron castings

How to cut costs in designing and and processing gray iron castings will be the subject of the series of one-day clinics sponsored throughout the country by the Gray Iron Founders' Society.

Intended for designers and engineers, the clinics will cover: 1) design possibilities exclusive with gray and ductile iron; 2) ultimate economies to be realized by "designing in" the properties of gray iron; 3) new services being applied by informed foundrymen; and 4) recently

USE THE 'SELECTOR'—You will find properties of most engineering materials, plus names and addresses of suppliers, in M/DE's *Materials Selector* reference issue, published last October.

HARD SMOOTH AND ACCURATE



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These balls are available in ALL SIZES, standard and special, from .005" to 5". Sizes from 1/64" to 1" are in stock.

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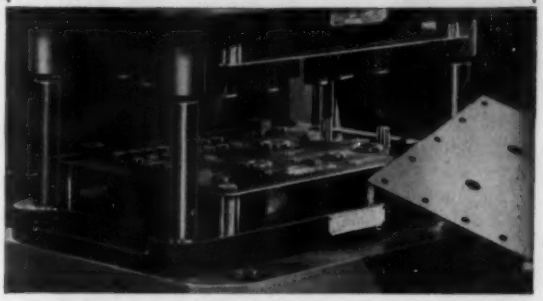

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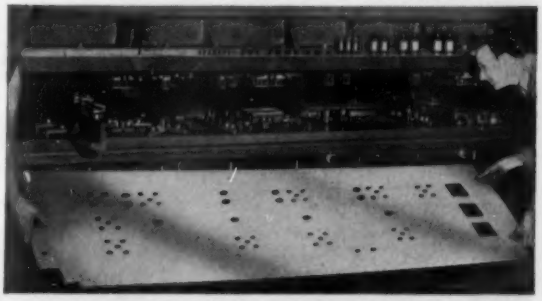

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News OF INDUSTRY

developed short cuts in designing castings.

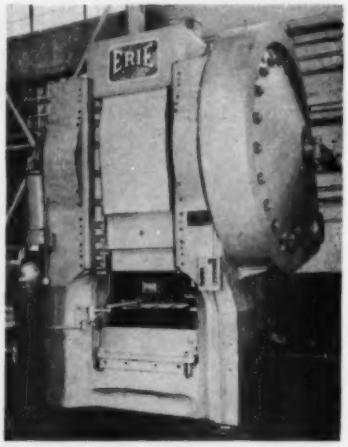
Classes will be limited to 40 men. A $25 registration fee will include a copy of the new 600-page *Gray Iron Castings Handbook*. For further information, contact Gray Iron Founders' Society, National City—East Sixth Bldg., Cleveland 14.

Epoxy tooling seminar

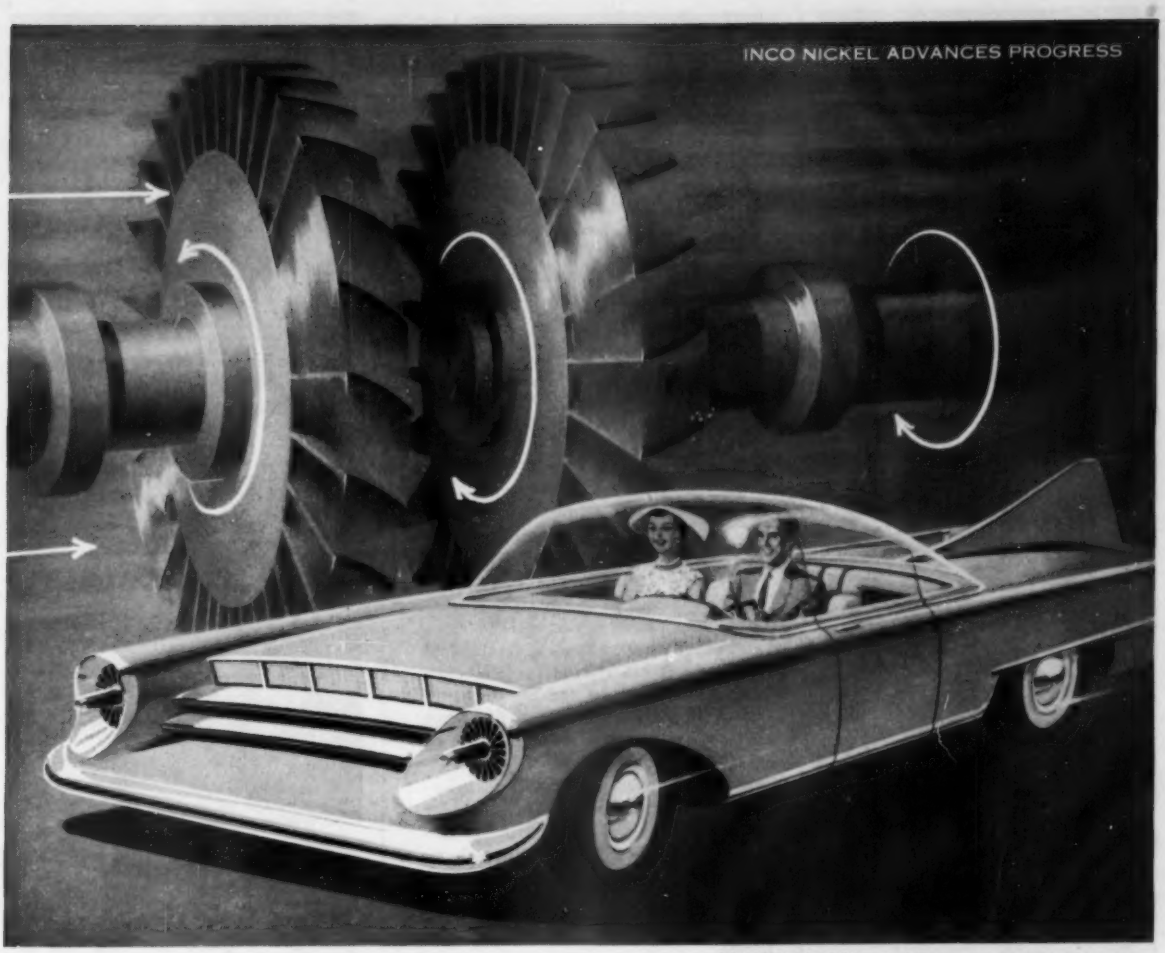
The year-long series of seminars arranged by Ren Plastics, Inc. is designed to explain the use of epoxy tooling materials. This series is scheduled for major U.S. cities.

Each seminar will be a one-day affair devoted to: 1) a discussion by Ren personnel of plastics tooling in general and new plastics materials and facilities in particular; and 2) demonstrations of various methods of building plastics tooling followed by a question and answer period.

A 30-min sound slide film will open the sessions. The film covers: physical characteristics of plastics



Automated forging—Shown above is what is claimed to be the world's first fully automated forging press. The 2500-ton press, developed by Erie Foundry Co., is designed for high volume forging of such parts as connecting rods, gear blanks, automotive and tractor valves, stem pinions, ring gears, track links and wheel hubs. A major additional advantage is the ability of the press to trim as well as forge.



This "windmill" or turbine, spun by hot gas, powers the turbocar. For such a hot spot, designers depend on Nickel to help them solve heat-resistance problems.

How Inco Nickel is helping develop your new gas turbine car of tomorrow

It will be power-packed: the gas turbine engine in your dream car of the future. In tomorrow's trucks and buses, too.

Only one spark plug—runs on kerosene

This new, power-packed engine is much lighter, much smaller than yours. It has far fewer parts. No pistons. No water system. Only one spark plug. And it runs on lower-grade fuels like kerosene.

Not yet in production!

Before this dream car becomes a showroom reality, engineers have a number of big problems to solve.

One of the engineers' problems—the one Inco Nickel is helping with—is metals. *Heat-resisting metals!*

Gas turbine engines operate up to 1600 degrees F. These temperatures step up corrosion. So the job is to develop alloys that can carry the load—that resist corrosion—at these jet-high temperatures.

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But the uses of nickel-containing alloys *are by no means limited to these industries.* There's a place for them in any field where heat, corrosion, stress and fatigue proves troublesome. Our new booklet, "High Temperatures Spur Use of Nickel-Base Alloys," points up this versatility. Write for a copy.

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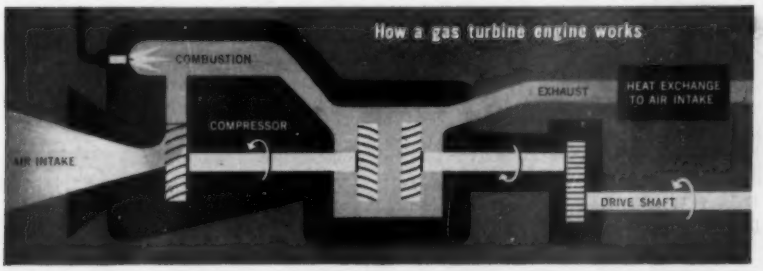

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News of Industry

used in tooling, savings that can be achieved, examples of plastics tooling in use today, limitations of plastics tooling, and future possibilities.

Movies on Plastics Listed in Catalogue

The *Motion Picture Film Catalogue of the Plastics Industry* has been revised and brought up to date.

The catalogue, assembled by the Society of the Plastics Industry, Inc., lists available motion pictures on various phases of the plastics industry—from raw materials, through manufacturing processes, to finished products. A brief description of each film, the conditions and the company or agency from which the film may be obtained are included. Some of the subjects covered in the films include: compression molding, injection molding, shell molding, transfer molding, polyethylene, synthetic resins, nylon, silicone, and many others.

The catalogue can be obtained from SPI, 250 Park Ave., New York 17.

Engineers

William G. Newton has been named to the newly created post of corporate industrial engineering manager, Beckman Instruments, Inc.

Archie L. Spratt has been named director of research and engineering, Metal Forming Corp., Div. of Vanadium-Alloys Steel Co.

Prof. Donald L. Katz, University of Michigan, has been elected president, American Institute of Chemical Engineers.

Frank P. Houpt is now manager, Systems Application Engineering Dept., Fischer & Porter Co.

Dr. David R. Stern has been named manager of research, American Potash & Chemical Corp.'s Los Angeles plant.

Wilfred H. Stewart has been appointed manager, engineering services, Refractories Div., H. K. Porter Co., Inc.

Robert W. Sheehan has been named plant superintendent, and **Frank**

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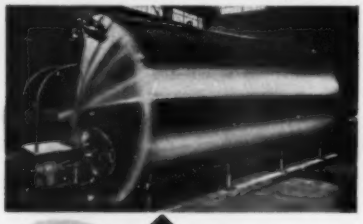

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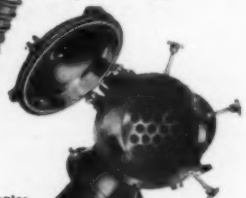

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The ideal solution, a one-piece steel casting, required accurate suspension of a huge core on a minimum number of points to produce a horizontal "tank" within consistent tolerances. One subsequent finishing problem involved economically "sealing" the core suspension holes by a method that would hold up in end use—*plus* pass radiographic inspection!

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News OF INDUSTRY

O'Connor has been appointed chief of research, development and material control, Du-Co Ceramics Co.

Edward K. Lefren has been named to the newly created position of manager of technical services, Engineering Dept., Hercules Powder Co.

Robert D. Scott has been named vice president, development, B. F. Goodrich Chemical Co.

Ethan A. Smith, Jr., has been named to the newly created position of manager, development engineering, Beryllium Corp.

George Lubin is now plastics consultant, Grumman Aircraft Engineering Corp.

Dr. Victor L. Erlich has been elected vice president and director of basic research and development, Reeves Bros., Inc.

Wilson T. Groves has been appointed chief metallurgical engineer, Dana Corp.

Frank J. Senters has been named director of engineering, and **A. C. Finalborgo** chief engineer, Sun Chemical Corp.

Harold D. Blake has been named chief engineer, Kolcast Industries, a division of Thompson Products, Inc.

Dr. Edward B. Saubestre is now assistant to the research director, Enthone, Inc., a subsidiary of American Smelting & Refining Co.

Howard B. Cary has been appointed director of the newly established Hobart Brothers Technical School, Troy, Ohio.

Dr. Arthur Clay Cope, Massachusetts Institute of Technology, has been awarded the Charles Frederick Chandler Medal, presented annually by Columbia University "in recognition of achievement in pure or applied chemistry."

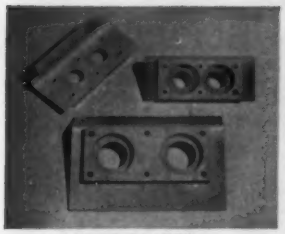
Ralph L. Hawks has been appointed chief ceramic engineer, stain department, Vitro Mfg. Co.

Dr. John H. Buck has been appointed vice president of engineering, BJ Electronics, Borg-Warner Corp.

James R. Parr has been named vice president and chief engineer, American Industries Co.

W. W. Wellborn is now technical director, Carbide Div., Firth Sterling Inc.

Dr. Marvin L. Granstrom has been named chairman, Dept. of Civil Engi-



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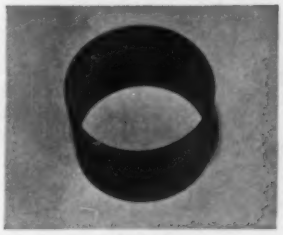
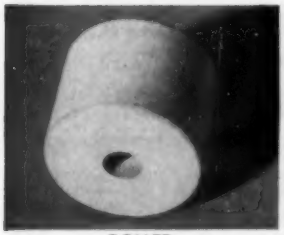


BUSHING

FORMED INSULATORS



ROLLER

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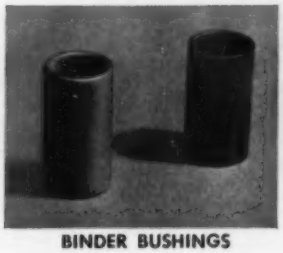

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Look what Diamond Vulcanized Fibre can do for you! And look what *you* or CDF can do with *it!*

If you can keep high-quality fibre clear of its worst enemy—moisture—you have the best economical insulating material you'd ever want for high arc-resistance, non-tracking, and long-time dielectric strength.

UNIQUE PROPERTIES • The high tensile, flexural, and impact strengths, the easy workability (ideal for screw machines), the Rockwell hardness (to R80), the light weight (half that of aluminum), the low cost, and the excellent electrical characteristics (arc-resistance up to 150 sec.) of CDF Fibre make it a highly attractive basic insulation for cost-conscious designers and purchasing men. Put these properties to work in your product.

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Send us your print or your problem, and we'll return technical literature. For the phone number of the CDF sales engineer nearest you, see Sweet's, Electronics Buyers' Guide, and other directories.

CDF makes Di-Clad printed-circuit laminates, Diamond Vulcanized Fibre, CDF products of Teflon, flexible insulating tapes, Dilecto laminated plastics, Celoron molded products, Micabond mica products, Spiral Tubing, Vulcoid.

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"MOLDED FIBER GLASS"?

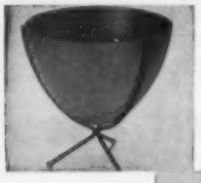
It's fiberglass reinforced plastic, custom molded by the affiliated MOLDED FIBER GLASS Companies.

It's one of the strongest, most durable materials known — a formulation of glass fibers and polyester resin possessing many superior physical features and infinite design possibilities.

When skillfully molded by the exclusive MOLDED FIBER GLASS process (using made-to-fit preforms and matched metal dies), it forms products which do the job better, last longer, and are often more economical to produce.

The affiliated MOLDED FIBER GLASS Companies are pioneers in and world's largest producers of mass-produced fiberglass reinforced plastic parts.

If you are looking for ways to make a better product, at less cost — investigate MOLDED FIBER GLASS. Consultation with MOLDED FIBER GLASS engineers entails no cost or obligation. Write for new engineering handbook.



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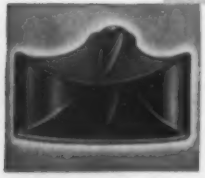


Molded Fiber Glass horns address the world

Molded Fiber Glass Company

4421 Benefit Avenue, Ashtabula, Ohio

News of Industry

neering, College of Engineering, Rutgers University.

Dr. John N. Cosby has been appointed director of research and development, Barrett Div., Allied Chemical Co.

Dr. Charles G. Miller has been appointed director of research and development, Isotopes Specialties Co., a division of Nuclear Corp. of America.

Companies

Greenlee Bros. & Co. has purchased **Buss Machine Works** and its subsidiary, **B & T Machinery Co.**

A. O. Smith Corp. has formed a new Reinforced Plastics Div. and has named James F. Donnelly, Sr., general manager.

Whitehead Metals, Inc. is the new name of Whitehead Products Co., Inc.

Bunting Brass & Bronze Co. has formed a Research and Development Dept. with Dr. Ralph A. Schaefer as its director.

Kennecott Refining Corp. has begun construction of a 16,500-ton-per-month electrolytic copper refinery near Baltimore, Md.

Divco-Wayne Electronics is a new division of Divco-Wayne Corp., Richmond, Ind.

Borden Chemical Co. has begun operations in its new $4-million polyvinyl chloride plant addition in Leominster, Mass.

Hamilton Cosco Inc. is the new name for **Hamilton Mfg. Corp.**, Columbus, Ind.

Simmonds Aerocessories, Inc. has organized a Specialty Valve Dept.

Hammond Valve Corp., a subsidiary of Consolidated Diesel Electric Corp., has acquired **Hammond Brass Works, Inc.**

Marquardt Aircraft Co. has acquired the assets of **Associated Missile Products Co.**, a division of American Machine and Foundry Co.

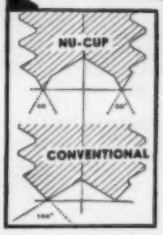
Cumberland Chemical Corp. is a new company formed jointly by **Air Reduction Co., Inc.**, and **Mastic Tile Corp. of America.**

Smith, Scherr & McDermott, industrial designers, have opened a new office at 10 W. 56th St., New York City.

Bissell Carpet Sweeper Co. has received the 1958 Bachner Award for

MORE HOLDING POWER AT LESS COST WITH SETKO

"SLABBED HEAD with NU-CUP Point" Set Screws!



Setko Slabbed Head Set Screws are real money savers. They cost less than comparable hexagon or fluted socket set screws, yet they take greater tightening pressures... Up to 50% more torque without damaging.

Holding power can be even further increased when furnished with Setko's own NU-CUP, the patented holding cup point that has a 42% sharper cutting angle. Cuts are deeper and in a full circle.

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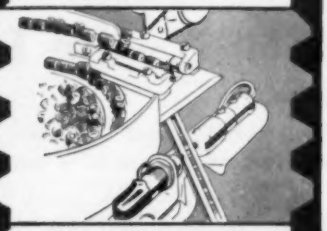
Now is the time to cash in on Setko's advanced method of hopper feeding... You get *faster* insertion rates over manual feeding — almost double... *Better* insertions, uniform driving pressure, better quality control. *Less expensive*, less labor is needed ... And, floor loss is eliminated.



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Shows how and where to use over 1,001 combinations of particular applications.

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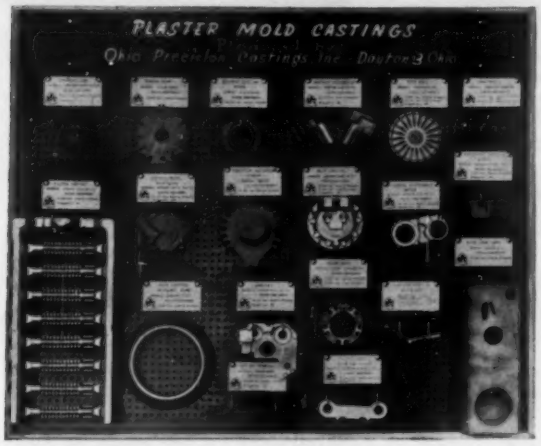

Every one of these OPC castings represents time and money saved by a manufacturer. You, too, can save time and money by having OPC produce your small parts to the most exacting tolerances, whether you need just a few for experimental purposes or thousands for a production run. Our illustrated brochure shows how and why.

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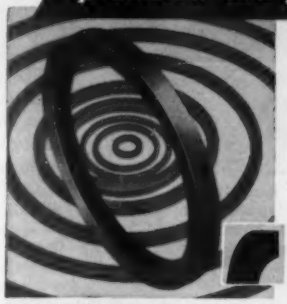

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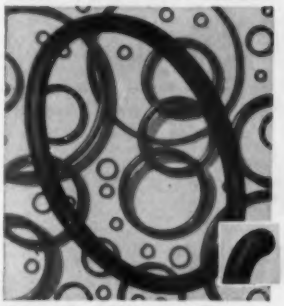
. . . rectangular-section rings that give high performance, low-cost sealing for most static and some moving applications. Interchangeable with standard o-rings . . . need no special tooling. A Goshen exclusive.



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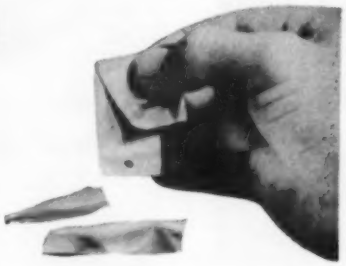

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News OF INDUSTRY

outstanding achievement in the industrial application of molded plastics. The winning entry was a unique home rug cleaning applicator utilizing eight different plastic materials.

Ciba Co., Inc.'s Plastics Div. has merged with its affiliate, **Ciba Products Corp.**

Corwith Corp., a newly-formed subsidiary of **Crane Co.**, will handle Government-sponsored research and development work.

Rexall Drug Co. has purchased **Tupper Corp.** and its subsidiaries, manufacturers and distributors of plastics products.

Glass Beads Corp., Latrobe, Pa., is a newly-formed company which will produce glass sealing beads used in electrical and electronic products.

National Science Foundation has moved to new quarters at 1951 Constitution Ave., Washington 25, D. C.

Minneapolis-Honeywell Regulator Co. has purchased **Marion Electrical Instrument Co.**, Manchester, N. H.

Trilan Corp. is the new name for **Consolidated Aircraft Products**, El Segundo, Calif.

Societies

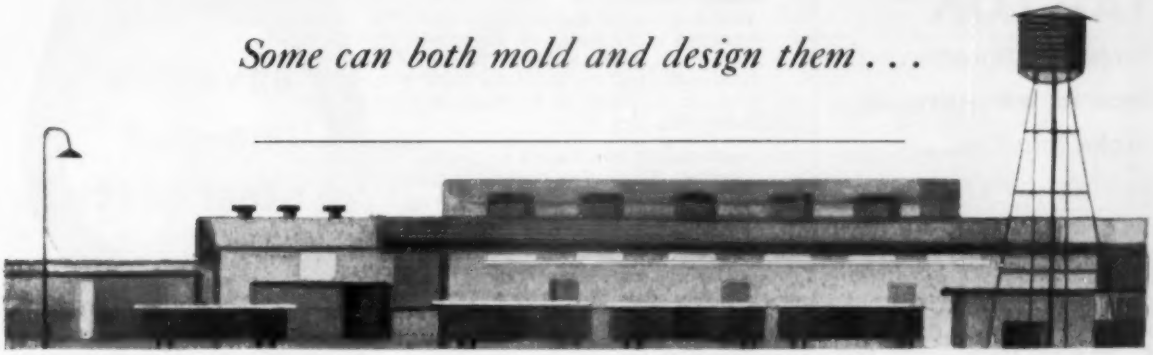
American Institute of Electrical Engineers has awarded the honor of Fellow to its following members: Carl H. Bjorquist, Bonneville Power Administration; Theodore W. Stringfield, Bonneville Power Administration; Albert Hansen, Jr., Donnell D. MacCarthy, C. Russell Mason and Myron S. Wilson, General Electric Co.; William C. White, Northeastern University; Robert R. Wagstaff, United Engineers Constructors, Inc.

Investment Casting Institute has elected the following 1959 officers: president—Robert R. Miller, Precision Metalsmiths, Inc.; vice president—John H. Morison, Hitchiner Mfg. Co.; and treasurer—K. W. Thompson, K. W. Thompson Tool Co. New directors are: Dr. Jack Keverian, General Electric Co.; and E. A. Democh, York Castings, Inc.

Structural Clay Products Institute has re-elected the following officers for 1958-59: president—Kenneth W. Dunwody Cherokee Brick & Tile Co.; vice president—Paul B. Belden, Jr., Belden Brick Co.; treasurer—George

Hundreds of companies can mold plastics . . .

Some can both mold and design them . . .



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General American's Plastics Division gives you advantages that no other molder in the world can offer!

- The largest and most varied molding facilities in the industry, with compression presses up to 2000 tons (including reinforced plastics), injection presses up to 300 ounces, and large extruding and vacuum-forming machines.
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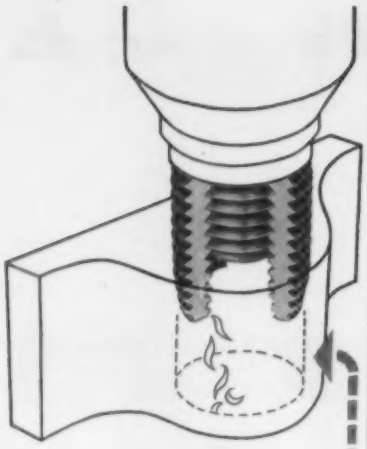

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threaded insert...

taps its own threads...

locks itself in...

in ONE OPERATION

With TAP-LOK inserts you get long thread life in wood, plastic, aluminum or other soft materials, as well as in harder materials where thread wear is a problem. TAP-LOKs cut their own threads and, because they force their way into the parent material, they lock themselves in permanently. Only one operation is needed, making TAP-LOK's initial cost the *only* cost ... thus their *installed* cost is lower than that of any other threaded insert.

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H-Series: — A heavy walled insert with truncated root external thread and three-hole cutting edges for hard-to-tap higher-strength materials and to meet MIL and other specs calling for Class 3B thread fit for gaging after installation

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News of Industry

Gammie, Illinois Brick Co.; and secretary—Joseph J. Cermak, SCPI staff.

Ultrasonic Mfgrs. Assn. has elected the following 1958-59 officers: president—Jack T. Welch, Sheffield Corp.; vice president—Norman G. Branson, Branson Ultrasonic Corp.; secretary—Robert L. Rod, Accoustica Asso. Inc.; and treasurer—Stanley E. Jacke, Detrex Chemical Industries, Inc.

Powder Metallurgy Parts Mfgrs. Assn. has named the following new members to its board of directors: P. J. Failla, Johnson Bronze Co.; W. L. Strawbridge, Sr., Precision Metal Products Co.; and R. L. Pettibone, Eaton Mfg. Co.

American Welding Society has established an information center located at 33 W. 39th St., New York 18.

Plumbing Brass Institute has elected the following officers: president—John H. Pimm, Bridgeport Brass Co.; first vice president—Roger Milroy, Lee Bros. Foundry Co. Inc.; second vice president—M. W. Peterman, Milwaukee Faucets, Inc.; and treasurer—Nate Cohn, Dearborn Brass Co.

American Society of Mechanical Engineers announces the following recipients of national awards: Allison K. Simons, Bostrom Research Laboratories—Pi Tau Sigma Gold Medal; Wilfred Fishwick, University College of Swansea, and S. A. Tobias, Cambridge University, England—Blackall Machine Tool and Gage Award; Harold J. Rose, Bituminous Coal Research, Inc.—Worcester Reed Warner Medal; Thomas P. Goodman, General Electric Co.—Melville Medal; and Theodore von Karman, NATO Advisory Group for Aeronautical Research and Development, Arpad L. Nadai, formerly with Westinghouse Research Laboratories, and Sir Geoffrey Ingram Taylor, former Yarrow Research Professor of the Royal Society—Timoshenko Medal.

Instrument Society of America has elected the following 1958-59 officers: president—Henry C. Frost, Corn Products Refining Co.; president-elect-secretary—John Johnston, Jr., E. I. du Pont de Nemours & Co., Inc.; vice president, standards and practices department—Glen G. Gallagher, Fluor Corp., Ltd.; vice president, technical department—Thomas C. Wherry, Phillips Petroleum Co.; treasurer — Howard W. Hudson, Panellit, Inc.; vice president, District

Have you compared the cost per foot of the solid stock you may now be using with the per foot cost of tubing? By designing and building with hollow steel tubing to begin with instead of solid stock, designers and engineers have often found that a great deal of money can be saved. This can also mean a tremendous reduction in overall unnecessary weight without sacrificing in the least any needed strength or durability. In fact the opposite is often true. The use of steel tubing can mean reduced cost of material and weight with adequate strength. Standard is anxious to analyze your mechanical requirements and suggest where possible how tubing can help your specifications take shape...at a lower cost.

FREE: A vitally important table comparing the weight savings of hollow tubing versus solid stock to help you reduce steel costs. Write address below.

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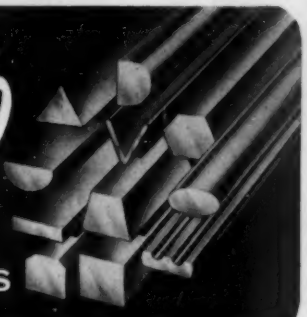
SHAPED WIRE
CUTS COSTS



- Shaped wire cuts costs where it counts most—on forging, stamping, rolling and machining for moldings, product trim or other fabrication.
- Available in a wide range of tempers, finishes and analyses in low and medium low carbon steels—including #3 finish wire for electroplating.
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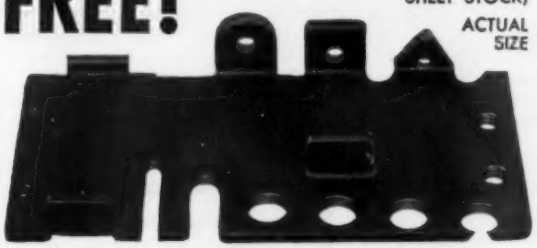

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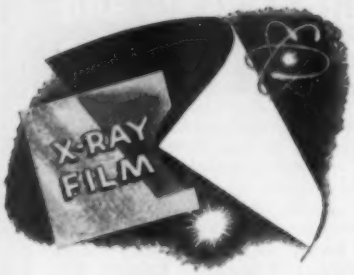

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News OF INDUSTRY

II—Charles A. Kohr, Radio Corp. of America; vice president, District IV —George L. Kellner, Linde Co.; vice president, District VIII—John A. See, Boeing Airplane Co.; and vice president, District X—J. R. Rogers, Bristol Co., Ltd. The award of honorary membership has been given to Dr. William G. Brombacher, formerly with the National Bureau of Standards.

Meetings

AMERICAN INSTITUTE OF MINING, METALLURGICAL, AND PETROLEUM ENGINEERS, annual meeting. San Francisco. Feb 15-19.

STEEL FOUNDERS' SOCIETY OF AMERICA, 57th annual meeting. Chicago. Mar 16-17.

AMERICA SOCIETY FOR METALS, 11th Western metal exposition. Los Angeles. Mar 16-20.

INSTITUTE OF RADIO ENGINEERS, INC., national convention. New York City. Mar 23-26.

AMERICAN SOCIETY FOR QUALITY CONTROL, Rochester Section, 15th annual quality control clinic. Rochester, N.Y. Mar 26.

AMERICAN INSTITUTE OF MINING, METALLURGICAL, AND PETROLEUM ENGINEERS, conference on physical metallurgy of stress-corrosion fracture. Pittsburgh. Apr 2-3.

AMERICAN WELDING SOCIETY, 40th annual convention and welding exposition. Chicago. Apr 6-10.

METAL POWDER INDUSTRIES FEDERATION, annual meeting. Detroit. Apr 20-22.

INSTITUTE OF ENVIRONMENTAL ENGINEERS, 3rd annual technical meeting and equipment show. Chicago. Apr 22-24.

METAL TREATING INSTITUTE, spring meeting. Hollywood, Calif. Apr 22-26.

ELECTROCHEMICAL SOCIETY, spring meeting. Philadelphia. May 3-7.

AMERICAN FOUNDRYMEN'S SOCIETY, 62nd foundry show and castings congress. Cleveland. May 19-23.

4th annual Design Engineering Conference, American Society of Mechanical Engineers. Convention Hall, Philadelphia. May 25-28.

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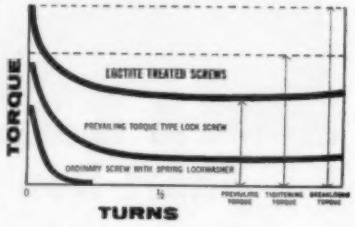

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TECHNICAL LITERATURE

(cont'd from p 42)

Books

Glass Engineering Handbook: 2nd Edition. *E. B. Shand. McGraw-Hill Book Co., Inc., New York. 1958. Cloth, 6 by 9 in., 488 pp. Price $10*

Here is a highly informative book on the composition, manufacture, properties and uses of glass as an engineering material. It gives data on the use of glass products in industry and research, including the nuclear, electronic, guided missile and automotive fields.

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Thermal, mechanical, optical, chemical and electrical properties, as well as manufacturing tolerances and design, are thoroughly discussed.

Symposium on Radiation Effects on Materials: Volume 2. *ASTM Special Technical Publication No. 220, American Society for Testing Materials, Philadelphia. 1958. Cloth, 6 by 9 in., 140 pp. Price $3.75*

Volume 1 of this series was reviewed in the June '58 issue of this magazine, p 228. The present volume, of value to those interested in the design and operation of nuclear reactors, is concerned with the selection of structural materials for nuclear power plant components; measurement of electrical resistivity of radioactive metals; tension testing of irradiated materials at high temperatures; and radiation stability of molybdenum-uranium fuel alloys.

Extrusion of Plastics. *E. G. Fisher. Interscience Publishers, Inc., New York. 1958. Cloth, 5½ by 8½ in., 122 pp. Price $3.50*

Well illustrated with photos and diagrams this British book discusses the extrusion of plastics from both the practical and theoretical viewpoint. The book's eight chapters contain information on: basic principles of extrusion; single and multi-screw extrusion machines; materials for extrusion; the complete extrusion process; and the extrusion of thermosetting plastics.

ASTM Standards 1958: Part 2-Non-Ferrous Metals (Specifications), Electronic Materials. *American Society for Testing Materials, Philadelphia. 1958. Cloth, 6 by 9 in., 1336 pp. Price $10.*

This triennial publication contains the formally adopted ASTM standards and the ASTM tentative specifications, methods of test and definitions for nonferrous metals and electronic materials. Tentative revisions will appear in the 1959 and 1960 Supplements.

Standards are given for copper and copper-base alloys; nickel and nickel-base alloys; aluminum and magnesium and their alloys; metallic materials for electrical heating, electrical resistance and electrical contacts; materials for electron tubes and semiconductor devices; die cast metals and alloys; electrodeposited metallic coatings; metal powders and metal powder products; and miscellaneous nonferrous metals and

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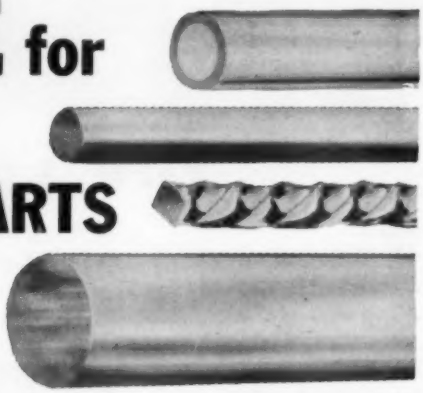

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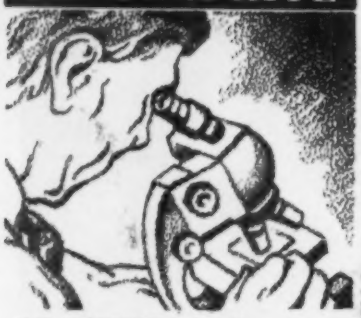

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TECHNICAL LITERATURE

alloys. The book contains hardness conversion tables for metals, and definitions of terms relating to heat treatment of metals.

Nuclear Reactor Metallurgy. *Walter D. Wilkinson and William F. Murphy. D. Van Nostrand Co., Inc., Princeton, N. J. 1958. Cloth, 6¼ by 9¼ in., 390 pp. Price $5.60*

The contents of this book are lectures presented at Argonne National Laboratory's course in nuclear reactor metallurgy. The treatment, primarily descriptive and qualitative, assumes no previous training in metallurgy.

Uranium, which is likely to remain the most significant metal in reactor technology, is thoroughly covered. The authors describe its ores, production, alloys, metallography, thermal properties, fabrication, corrosion and radiation effects. A discussion of the special problems presented by plutonium, thorium, beryllium and zirconium follows. Also discussed are liquid metals, ceramics and metallic materials with large cross sections.

Zone Melting. *W. G. Pfann. John Wiley & Sons, Inc., New York. 1958. Cloth, 6 by 9 in., 250 pp. Price $7.50*

Written by a man who pioneered the research and development of zone melting, this book covers both theory and practice and spells out potentialities of crystallization as yet unexploited. The various chapters in the book contain information on how to build and operate zone refiners; computed zone refining curves showing impurity concentrations after any number of passes; and continuous zone refining methods.

Progress in Semiconductors: Volume 3. *Edited by A. F. Gibson, P. Aigrain and R. E. Burgess. John Wiley & Sons, Inc., New York. 1958. Cloth, 6 by 9 in., 210 pp. Price $8.50*

Subjects covered in this book are: 1) magnetoresistivity and chemical purification of germanium and silicon; 2) electronic conductivity of silver halide crystals; 3) silicon junction diodes; 4) lifetime of excess carriers in semiconductors; and 5) electronic processes in cadmium sulfide.

Powder Metallurgy in Nuclear Engineering. *Organized by H. H. Hausner. American Society for Metals, Cleveland. 1958. Cloth, 6 by 9 in., 284 pp. Price $8.50*

Subject matter in this book's 15 chapters ranges from general metallurgical problems in the design of nuclear reactors to safe handling of pyrophoric and radioactive metal powders. Powder metallurgy of zirconium, uranium, thorium, beryllium and various alloys is discussed, as are metal powders, preparation of metal powders for reactors, ceramic fuel materials and related topics. The book has 243 literature references and 100 charts, tables and graphs.

Report on Elevated-Temperature Properties of Chromium Steels (12-27%). *Prepared by W. F. Simmons and H. C. Cross. American Society for Testing Materials, Philadelphia. 1958. ASTM Special Technical Publication No. 223. Paper, 8½ by 11 in., 117 pp. Price $4.25*

This graphic summary includes data on tensile strength, yield strength, elongation, rupture and creep properties. Twenty-three alloys are covered.

Gum Plastics (Rubber-Modified Plastics). *M. S. Thompson. Reinhold Publishing Corp., New York. 1958. Plastics Applications Series. Cloth, 5¼ by 7½ in., 200 pp. Price $4.50*

Illustrated with tables and graphs, this book treats the subject of polystyrene polymers, ABS (acrylonitrile-butadiene-styrene)

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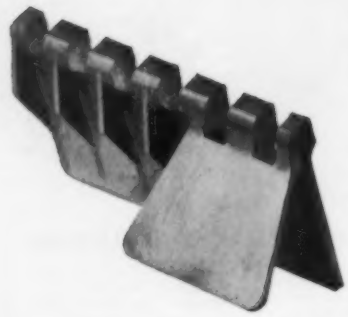

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TECHNICAL LITERATURE

polymers, and rigid polyvinyl chloride polymers. The author describes their advantages in terms of product improvement, and shows how certain disadvantages of these materials can be overcome. Special attention is given to applications and new compounds.

Modern Materials: Advances in Development and Applications—Volume 1. *Edited by H. H. Hausner. Academic Press Inc., New York. 1958. Cloth, 6 by 9 in., 413 pp. Price $13.50*

This book is designed to acquaint the engineer with the properties and characteristics of many types of materials for entirely new engineering applications. The use of mathematics is kept to a minimum, and each article, prepared by an expert, is presented in a manner useful to both the specialist and nonspecialist. The book covers such topics as new developments in wood; synthetic rubbers for special service conditions; fiber materials; high voltage insulation papers; special glasses for nuclear engineering applications; properties of ceramics; geramium and silicon; and zirconium.

Reports

Strength of stainless COMPRESSIVE STRENGTH AND CREEP OF 17-7 PH STAINLESS STEEL PLATES AT ELEVATED TEMPERATURES. *Bland A. Stein, Langley Aeronautical Laboratory. July '58. 33 pp. Available from National Advisory Committee for Aeronautics, 1512 H St. NW, Washington 25, D. C. (TN 4296)*

Compressive strength and creep properties of 17-7 PH stainless steel plates from room temperature to 1000 F. Test results are compared with data predicted by semi-empirical methods.

Arc welding RECOMMENDED SAFE PRACTICES FOR INERT-GAS METAL-ARC WELDING: 2ND EDITION. *1958. 20 pp. American Welding Society, 33 W. 39th St., New York 18, N. Y. Price $1 (AWS A6.1)*

All known potential safety hazards peculiar to the inert-gas metal-arc process are covered in the report. It focuses attention on the hazard of trichloroethylene when used in the vicinity of inert arc welding. Also included: data on carbon dioxide shielding.

Enameled aluminum TENTATIVE SPECIFICATIONS FOR PORCELAIN ENAMEL ON ALUMINUM AS USED FOR SIGNS AND ARCHITECTURAL APPLICATIONS. *1958. Porcelain Enamel Institute, 1145 19th St., NW, Washington 6, D. C. Price $10 (ALS-105)*

Included are requirements for base metal, finish and thickness of coatings. Also cited are performance standards for retention of adherence, acid resistance, color retention and abrasion resistance as determined by the test methods given.

Properties of lead DETERMINATION OF THE MECHANICAL PROPERTIES OF A HIGH PURITY LEAD AND A 0.058% COPPER-LEAD ALLOY. *T. E. Tietz, Stanford Research Institute. Apr '58. 43 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $1.25 (PB 131818)*

The purpose of this study was to identify the mechanical properties of a high purity lead and a lead-0.058% copper alloy at temperatures of 100 F, 175 F, 250 F and 325 F. The data obtained are summarized in graphs and tables.

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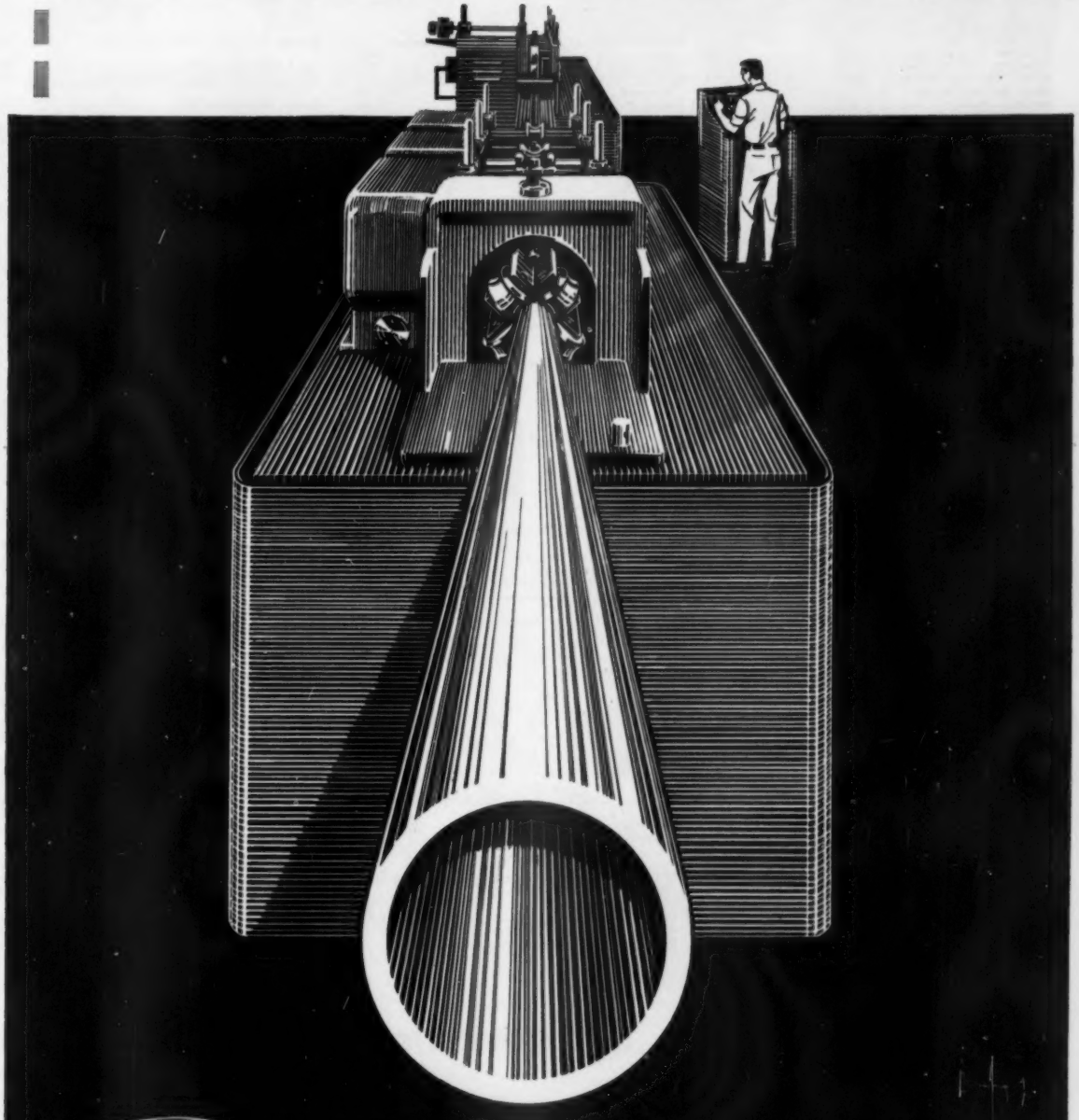

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Acushnet Process Co. 208
Allegheny Ludlum Steel Corp. 137
Allied Research Products, Inc. 69
Alloy Products Corp. 202
Amchem Products, Inc. 28
American Brass Co. ..... 2nd Cover
American Manganese Bronze Co. 211
American Manganese Steel Div., American Brake Shoe Co. 203
American Nickeloid Co. 152
American Sealants Co. 212
American Smelting & Refining Co., Federated Metals Div. 49
Ampco Metal, Inc. 44
Amplex Div., Chrysler Corp. 131
Anaconda Aluminum Company 122
Armco Steel Corp. 55
Art Wire & Stamping Co. 202
Atlantic Casting & Engineering Corp. 16
Auburn Manufacturing Co. 221

Bethlehem Steel Co. 43, 169, 191
Bishop, J., & Company, Platinum Works 76
Bridgeport Brass Co. 167
Bunting Brass & Bronze Co. 132
Byers, A. M., Co. 155

Cannon-Muskegon Corp. 62
Carpenter Steel Co. 193
Carpenter Steel Co., Alloy Tube Div. 48
Cast Optics Corp. 174
Celanese Corp. of America, Plastics Div. 163
Cerro de Pasco Sales Corp. 211
Chace, W. M., Co. 162
Chemical Products Corp. 26, 27
Chicago Rawhide Manufacturing Co. 29
Chromalloy Corp. 136
Cibo Products Corp. 183
Cincinnati Milling Machine Co., Meto-Dynamics Div. 129
Coating Products, Inc. 146
Colonial Plastics Manufacturing Co. 190
Commercial Plastics & Supply Corp. 217
Connecticut Hard Rubber Co. 221
Continental-Diamond Fibre Corp., Subsidiary of Budd Co. 205
Continental Felt Co. 217
Continental Rubber Works 140
Continental Steel Corp. 211
Cooper Alloy Corp. 171
Coors Porcelain Co. 181
Corning Glass Works 77
Crane Packing Co. 138

Dodge Steel Co. 58
Dollin Corp. 217
Dow Corning Corp. 119, 120
du Pont de Nemours, E. I., & Co., Inc., Elastomer Chemicals Dept. 32
du Pont de Nemours, E. I., & Co., Inc., Film Dept. 139
Duraloy Co. 184
Durez Plastics Div., Hooker Chemical Corp. 51

Eastman Chemical Products, Inc., Plastics Div. 60, 61
Engelhard Industries, Inc. 30, 31
Enjay Co., Inc. 177

Fansteel Metallurgical Corp. 150
Farley & Loetscher Manufacturing Co., Plastics Div. 172
Felters Co. 72
Formica Corp., Subsidiary of American Cyanamid Co. 22, 23
Frasse, Peter A., & Co., Inc. 50
Frontier Bronze Corp. 14

General American Transportation Corp., Kanigen Div. 52
General American Transportation Corp., Plastics Div. 209
General Extrusions, Inc. 221
Goodrich, B. F., Co. 6
Goodrich, B. F., Chemical Co. 5
Goodrich-Gulf Chemicals, Inc. ..... 3rd Cover
Goshen Rubber Co., Inc. 207
Great Lakes Carbon Corp., Electrode Div. 216
Gries Reproducer Corp. 156
Groov-Pin Corp. 210

H & H Tube and Manufacturing Co. 141
Hamilton Foundry & Machine Co. 142
Handy & Harman 74
Harshaw Chemical Co. 75
Haynes Stellite Co., Div. of Union Carbide Corp. 24, 25

Industrial Tectonics, Inc. 198
International Nickel Co., Inc. 2, 201

Jones & Laughlin Steel Corp., Stainless and Strip Div. 17

Kennametal, Inc. 176
Keystone Steel & Wire Co. 153
Knowlton Brothers, Inc. 212
Kopp Glass, Inc. 164
Koppers Co., Inc., Plastics Div. 46, 47

Laminated Shim Co., Inc. 130
Lancaster Glass Corp. 166
Lepel High Frequency Laboratories, Inc. 199

Malayan Tin Bureau 128
Malleable Castings Council 70, 71
Mallory, P. R., & Co., Inc. 188
Mallory-Sharon Metals Corp. 34
Marbon Chemical Div., Borg-Warner Corp. 133
McLouth Steel Corp. 33
Mesa Plastics Co. 218
Metal & Thermit Corp. 54
Metallizing Engineering Co., Inc. 63
Metals & Controls Corp., General Plate Div. 196
Milford Rivet & Machine Co. 214
Minnesota Mining & Manufacturing Co., Reinforced Plastics Div. 18, 19
Mobay Chemical Co. 215
Molded Fiber Glass Co. 206
Monsanto Chemical Co., Organic Chemicals Div. 185
Morganite, Inc. 148
Mosinee Paper Mills Co. 203
Mueller Brass Co. 20, 21

National Tube Div., United States Steel Corp. 189
National Vulcanized Fibre Co. 194
Neilson Chemical Co. 207
New Jersey Zinc Co. 8, 9
Northwest Chemical Co., Inc. 145
Norton Co., Electrochemical Div. 173
Norton Co., Refractories Div. 135

Ohio Precision Castings, Inc. 207
Olsen, Tinius, Testing Machine Co. 144

Perony Equipment Co. 199
Plastic Metals Div., National-U.S. Radiator Corp. 180
Polymer Corp. 192
Porcelain Enamel Institute 56, 57
Precision Tube Co. 216
Pressed Steel Tank Co. 182

Ransburg Electro-Coating Corp. 168
Raybestos-Manhattan, Inc., Adhesive Dept. 59
Raybestos-Manhattan, Inc., Plastic Products Div. 186
Reichhold Chemicals, Inc. 13
Reinhold Publishing Corp. 170, 221
Republic Steel Corp. 66, 67
Resistoflex Corp. 178
Revere Copper & Brass, Inc. 15
Reynolds Chemical Products Co. 146
Rogers, Dayton, Manufacturing Co. 211
Rohm & Haas Co. 53
Ryerson, Joseph T., & Son, Inc. 78

St. Joseph Lead Co. 154
Sel-Rex Corp. 208
Set Screw & Manufacturing Co. 206
Shell Chemical Corp. 159
Solvay Process Div., Allied Chemical Corp. 175
Stackpole Carbon Co. 158
Standard Plastics Co., Inc. 200
Standard Tube Co. 210
Superior Tube Co 45
Swedlow Plastics Co. 127
Sylvania Electric Products, Inc., Parts Div. 151

Tempil Corp. 198
Thompson, H. I., Fiber Glass Co. 157
Timken Roller Bearing Co., Steel & Tube Div. ..... Back Cover
Torrington Co., Specialties Div. 160

Unitcast Corp. 204
United States Gasket Plastics Div., Garlock Packing Co. 134
United States Graphite Co. 64, 65
United States Stoneware Co. 149

Van Huffel Tube Corp. 179

WaiMet Alloys Co. 218
Wackesser Co. 217
Wairton Steel Co., Div. of National Steel Corp. 161
Westinghouse Electric Corp., Materials Manufacturing Dept. 68
Whistler, S. B., & Sons, Inc. 199
White Metal Rolling & Stamping Corp. 200
Williams-Bowman Rubber Co. 203
Wilson Mechanical Instrument Div., American Chain & Cable Co., Inc. 73
Witco Chemical Co. 143
Wolverine Tube Div., Calumet & Hecla, Inc. 147
Wyman-Gordon Co. 213

Yardley Plastics Co. 165
Yoder Co. 219
Youngstown Sheet & Tube Co. 187

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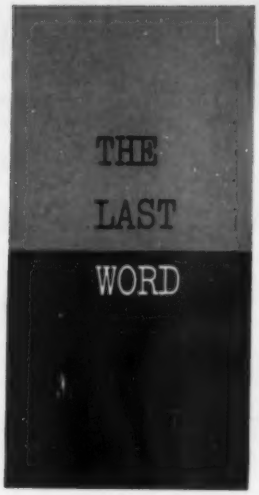
by H. R. Clauser
Editor



The New Unified Science of Materials

A few months ago I attended a rather unusual meeting on materials research. It was unusual chiefly because metallurgists, ceramicists, polymer chemists and physicists were together on the same platform. By chance, after the meeting, I overheard the polymer chemist and the metallurgist speaking to each other. This, in itself, was quite unusual. They were discussing their papers and were surprised and somewhat embarrassed by the fact that both had given essentially the same talk.

How could this happen? Well, each paper dwelt at some length on the fundamental character of a particular class of materials, and it became evident to both of them that what they had just said applied not only to one group of materials, such as plastics or metals, but to all materials.

Basic concepts are the same

What this meeting and this incident illustrate is the spreading awareness that the same fundamental concepts underlie the behavior of *all* materials. It is this awareness that is rapidly leading to a new unified science of materials.

A unified approach to materials has been a long time in developing. For one thing, it has had to wait for workers in the separate fields of metals, ceramics and polymers to fully recognize and understand the vital roles atomic and microscopic structure play in the behavior of materials. Perhaps it has been the great demand in recent years for materials to meet new and extreme requirements that has stimulated more workers in the separate fields to investigate the fundamental structures of their materials, and to make use of such things as quantum mechanics, kinetics, and solid-state physics to solve problems and to develop better materials.

The results of many of their fundamental studies have served to highlight the fact that structure is the common denominator of all materials, and that what is learned about one kind of material can be applied to others. Thus, studies in the deformation of crystals have resulted in the development of transistors, and at the same time have shed light on strength properties of metallic materials.

Education is helping

Another factor contributing to the rapid progress towards a unified approach to materials is recognition by the engineering schools of the basic similarities in all materials. The common practice—the chemical, metallurgical, mechanical and physics departments giving specialized materials courses—is being re-examined by many technical schools. Also, in a recent report on engineering education issued by the American Society for Engineering Education, the objectives and content of a new science of materials curriculum are outlined. Emphasis is on the study of the interrelationship among properties, service parameters, and structure of materials, and no attempt is made to treat the different classes of materials separately. Quite likely these reappraisals will result in establishing educational programs leading to a degree in the engineering science of materials.

Materials users will benefit

It is the user of materials who will benefit most from this new unified science of materials. By learning how materials are structured and how they behave at the microscopic and atomic level, materials producers will be better able to adapt existing materials to meet our needs and be better equipped to develop new materials. Thus, the new unified science of materials will create for us new synthetic materials and new combinations of materials with unheard-of properties. It will make tailor-made materials a reality. And it will make possible a complete and accurate definition of the behavior of materials under any one of several service parameters.

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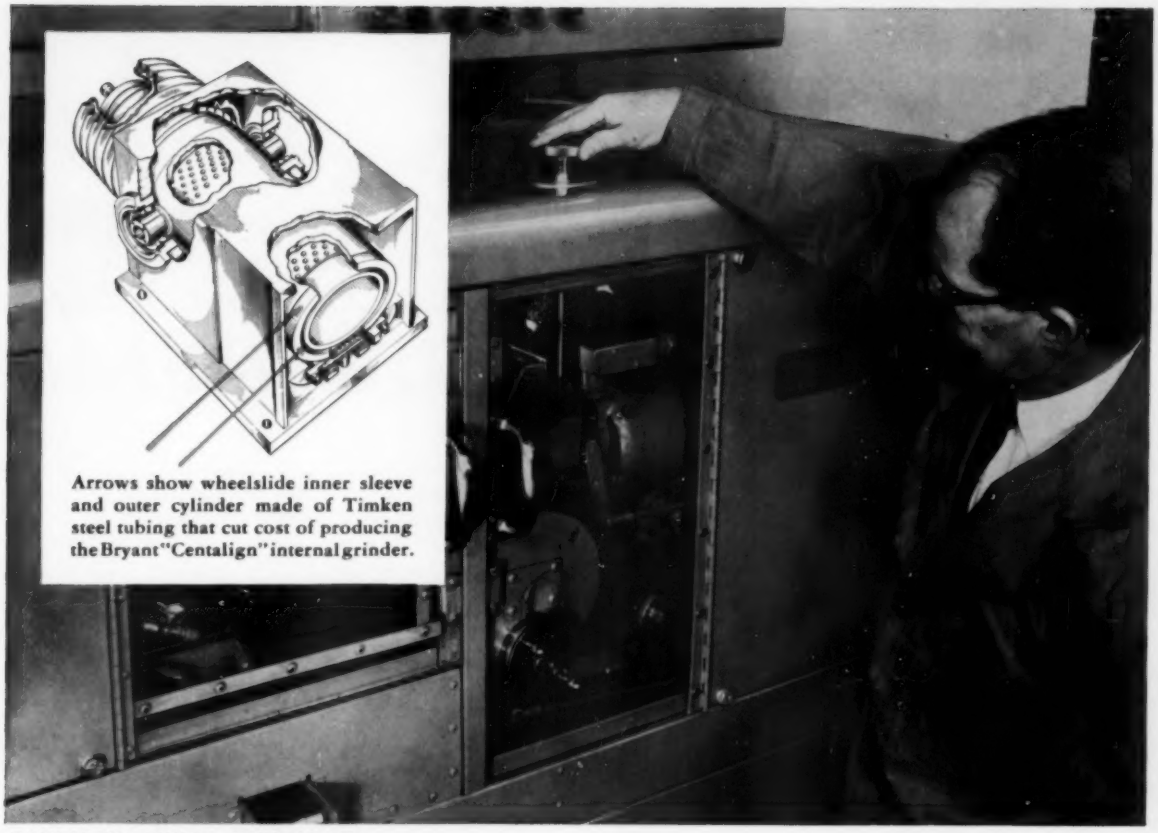

Arrows show wheelslide inner sleeve and outer cylinder made of Timken steel tubing that cut cost of producing the Bryant "Centalign" internal grinder.

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ENGINEERS at Bryant Chucking Grinder Co. wanted to reduce the cost of producing this "Centalign" internal grinder. They blamed high costs on spoilage due to weld checking and excessive machining time of the inner sleeve and outer cylinder of the wheelslide. When they consulted Timken Company metallurgists, these experts studied all angles of the problem. And they recommended a change to a certain grade and size of Timken® seamless steel tubing. Here's what happened.

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